Wetland Study Phase I Howth Co. Dublin

Final Report

prepared for Fingal County Council

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1 Introduction

Fingal County Council commissioned Scott Cawley Ltd. and Envirologic Ltd. to undertake a wide-ranging study of wetland habitats and their associated hydrological dynamics across the entire Howth Head peninsula of Co. Dublin (see Figure 1 for location map of the study area). Howth Head is considered to constitute all lands east of a line that runs from the western side of Sutton Golf Club through Sutton crossroads and along the western side of the Marine Hotel into Dublin Bay. The study area is approximately 11.5 km^2 (1,150 hectares).

This study incorporated information from the historic literature with regard to all wetland habitats and rare flora on Howth Head and assessed the current extent, diversity and status of these habitats today. Detailed vegetation and hydrological analysis of all existing wetlands was conducted, as well as an overall ranking of the botanical importance of each core site[1]. Furthermore, it was considered important to identify and assess, particularly in cases of loss or degradation of habitat, the most crucial pressures and threats (whether natural and/or man-made) to these wetland habitats, and to devise potential restoration measures that can be used to restore and/or enhance these sites in the coming years.

Figure 1 Study area, comprising the entire Howth Head peninsula.

[1] A core site is a wetland site which is deemed to be ecologically important – see Table 2 below for ranking of sites.

2 Methodology

2.1 Desk Study

The main aim of the desk study was to collate and map all available relevant data with respect to the study area and its wetland habitats. This collated data informed the preparation and planning of the field surveys and provided a set of potential wetland sites which were all later visited during fieldwork.

The desk study involved a review of the following available sources of information:

- Ordnance Survey Ireland mapping, aerial photography and historical mapping (including 6 inch and 25 inch historical maps) available from www.osi.ie and http://map.geohive.ie/;
- Cassini 6 inch historical maps available from https://maps.archaeology.ie;
- Online data available on European sites, habitat and species GIS datasets, and conservation objectives (and supporting) documents, as held by the National Parks and Wildlife Service (NPWS) from www.npws.ie;
- Townland shapefiles available from www.townlands.ie;
- Online protected species datasets held by the National Biodiversity Data Centre from http://maps.biodiversityireland.ie.
- Online data available on wetland sites as provided by Wetland Surveys Ireland[2] and Foss Environmental Consulting[3];
- Geological Survey of Ireland Groundwater Data Viewer information available from https://dcenr.maps.arcgis.com;
- Historical Google Earth orthophotography available at https://www.google.com/earth/;
- *The Flora of Howth: with map and introduction on the geology and other features of the promontory.* Hodges, Figgis, & Co., Dublin. (Hart, 1887);
- Consultation with expert botanist Dr. Declan Doogue, including the following report authored by Dr. Doogue;
    - Doogue, D.A. (2009) *Protecting Howth's Habitats.* Draft report for Howth Special Area Amenity Order.
- Other local botanical reports and literature, including:
    - Denyer, J. (2018) *Thormanby Hill Woodland: Survey and Monitoring 2018.* Report by Denyer Ecology for Scott Cawley Ltd.
    - Denyer, J. & Hodd, R. (2019) *Howth and Ireland's Eye Bryophyte Survey: Final Report*. Report by Denyer Ecology for Fingal County Council.

The companion hydrological report of Howth Head wetlands produced separately by Envirologic Ltd. (Envirologic, 2020) was used as the primary source of information for all of the hydrology sections in this report. These include section 3.1. Landscape, Geology, Soils, Hydrology and Hydrogeology, as well as the

[2] Available at:

https://wetland.maps.arcgis.com/apps/View/index.html?appid=e13b75c3bcab4932b992aa0169aa4a32&extent=-11.9317,51.0620,-3.9117,55.6465 [Last accessed 13th August 2020]

[3] Available at:

http://www.fossenvironmentalconsulting.com/wildlife-photography/map-of-irish-wetlands---20/index.html [Last accessed 13th August 2020]

Hydrology subsections of each of the individual site reports. This report was also an important source of information for the Recommendations subsections. The Envirologic (2020) report is also included in full in Appendix III of this report.

2.2 Field Surveys

2.2.1 Botanical surveys

Botanical surveys were undertaken by Alexis FitzGerald and Colm Clarke of Scott Cawley Ltd. from the 17th August 2020 to the 14th September 2020. All wetland habitats identified during the desk study were ground-truthed during an initial site visit (see Figure 4 for a location of map of all wetland habitat polygons). The purpose of this ground-truthing exercise was to confirm the presence or absence of a wetland feature and to classify the habitats present. All habitats present within these sites were classified according to the Irish Heritage Council Fossitt (2000) classification system and full vascular plant and bryophyte species lists were taken. Additional lands within the study area located beyond these sites identified during the desk study were also assessed for the presence of wetland features.

If a wetland habitat was confirmed to be present during the initial site visit, a more detailed botanical survey was undertaken at the site if it was deemed to be ecological important in the context of Howth Head. Detailed botanical surveys were undertaken at 12 of these identified core wetland sites (see Figure 5 for a location map of these sites). Botanical data was collected at a total of 44 standard 4m^2 vegetation sampling points (*i.e.* relevés) at wetland habitats located within each of the 12 identified core wetland sites. The locations of these relevés were selected with a view to representing and identifying the diversity of Irish Vegetation Classification (IVC) vegetation communities within the habitats.

In order to confirm the identification of the vegetation community/sub-community present, botanical data collected at each relevé was uploaded onto and analysed using the online vegetation classification tool "*Engine for Relevés to Irish Communities Assignment*" (*i.e.* "*ERICA*")[4]. The output of ERICA comprises statistically reliable vegetation classification for each relevé recorded.

The vegetation communities present were further analysed with reference to community descriptions available on NBDC[5]. Some interpretation of and changes to the classifications were also made by the author, where it was deemed necessary.

The results of the surveys and the subsequent analysis are presented below, with detailed site-based reports provided (all relevé and classification data are available in Appendices I and 2). The sites were ranked in terms of their botanical importance following field surveys, with the most important sites containing either rare Dublin plant species and/or Annex I habitats. Sites without these features were ranked based on the diversity and quantity of wetland habitat/communities recorded within them during the field surveys, as well as taking into account the historic botanical importance of the sites and their relative potential for restoration/enhancement measures.

Vascular plant nomenclature and English names follow Stace (2019), whilst bryophyte nomenclature follows Atherton *et al.* (2010).

2.2.2 Hydrological surveys

The companion hydrological report produced by Colin O'Reilly of Envirologic (2020) (see Appendix III for full report) details the methodology by which the hydrological surveys were completed. In summary, the

[4] ERICA is a web application that allows you to assign your own vegetation data to the communities of the Irish Vegetation Classification (IVC). It is accessible at: https://biodiversityireland.shinyapps.io/vegetation-classification/

[5] NBDC (2020). *National Vegetation Database: explore classification*. Published online. Available at https://www.biodiversityireland.ie/projects/national-vegetation-database/irish-vegetation-classification/explore. Searched on 23rd September 2020.

identified wetland features (via desktop study) were ground-truthed to assess whether they still existed. Where present a desk and field-based assessment of their current status in terms of ecology and hydrology was carried out. For wetland features no longer present the likely pressures associated with their disappearance was surmised.

Following discussion with the Consultant Ecologist (Scott Cawley) a shortlist of 12 sites was drawn up, with these considered to be most valuable (or potentially most valuable) in terms of supporting important plant communities. Guideline criteria to be recorded at shortlisted wetland features included:

i) extents and depth of wetted feature,

ii) ground and surface water elevation,

iii) inferred seasonal min./max. water level,

iv) inflow/outflow points and elevations,

v) flowrate,

vi) artificial drainage features and elevations,

vii) ground and aerial photograph (where feasible),

viii) evidence of pressures to quality (e.g. erosion, road runoff),

ix) visual clarity of water,

x) unstable hydrochemistry,

xi) any other relevant observations.

Additional features to be included at linear watercourses included:

i) cross-sectional dimensions,

ii) gradient,

iii) bed substrate,

iv) flowrate,

v) proximity of structures.

Items of interest, ground levels and water levels were surveyed using Trimble RTK R4 VRS with vertical and horizontal accuracy of 0.03 m. Easting and northing coordinates are relative to ITM, and elevations are tied to Malin Head datum. Unstable hydrochemistry was recorded at some sites using an InSitu Aquatroll. pH and DO parameters calibration was not satisfactory and these values should be re-tested following successful calibration before analysing any trends.

The report is intended to clearly communicate all findings from field surveys. Where relevant, additional analysis was performed to include geological, hydrological and hydrogeological controls, catchments, drainage patterns, pressures in terms of flow and quality. Site specific measures for protection and/or remediation were recommended to inform the next phase of works.

A naturalness index for watercourses in Howth is also presented. Using various criteria to describe stream hydromorphology, the guidance outlines how the following useful indices can be derived:

(i) River Habitat Survey (RHS) - a scheme developed for assessing the physical character and quality of river habitats;

(ii) Habitat Modification Score (HMS) - modification to the channel expressed as a score based upon type and extent of artificial features; and,

(iii) Habitat Quality Assessment score (HQA) - habitat quality of a site expressed as a score based upon extent and variety of natural features recorded.

Finally, a total of 31 prospective water quality monitoring locations is presented in detail.

3 Results

3.1 Landscape, Geology, Soils, Hydrology and Hydrogeology

3.1.1 Landscape, Geology and Soils

Howth Head can be considered broadly circular in shape, with a diameter of between 3 and 4 km. Up until around 3,500 years ago the peninsula was an island, though it is now connected to the mainland via a raised sand and gravel beach protruding westwards from the northwest corner at Sutton. The altitude of the study area ranges from sea level on the coasts to 171m above sea level at the summit of Ben Linn in the centre of the peninsula. The highest peaks of Howth are mostly found just south of the centre point of the peninsula:

i) Ben of Howth (Black/Ben Linn) (171 mOD) – notable by the presence of a telecommunications mast;

ii) Shielmartin (163 mOD) – surrounded to the west, north and east by Howth Golf Club while the southern slope falls to the south coast;

iii) Carrickbrack – east of Howth Golf Club and south of Ben of Howth;

iv) Muck Rock – raised bedrock plateau southwest of Deer Park Hotel which has a steep, north-facing escarpment;

v) Dun Hill – peak short distance south of Muck Rock, adjacent to the northern boundary of Howth Golf Club.

From this cluster of peaks raised ground extends east towards an inland peak referred to as the summit (close to the Summit Inn) and progress onto to the coastline. Steep cliffs define the eastern coastline between Dungriffin Promontory at the southern end, upon which Baily Lighthouse is sited, to the north-eastern tip, known as the Nose of Howth. This area of elevated land along the east coast is known as East Mountain. In the north-eastern corner of Howth the steep cliffs continue around the eastern half of the north coast to Balscadden Beach in an area known as Kilrock. Exposed bedrock abruptly gives way to a sand and gravel moraine in the village which forms Tower Hill, site of a Martello Tower. West of Howth village topography flattens out towards shallow sand dunes to the rear of Burrow Beach. From this low-lying area lands rise much more gradually through Howth Castle towards Deer Park Hotel. Similarly moderate gradients connect Deer Park Hotel to the western coastline, between which Deer Park Golf Course continues. The southern half of the west coast and the south coast is characterised by shallow cliffs and a rugged foreshore.

There are two major types of bedrock on Howth Head which are separated by a structural fault that runs from south-west, close to the entrance of Redrock, to north-east at Balscadden Beach. Most of the area is underlain by a bedrock of quartzite and mudstone (Cambrian metasediment), particularly in the east and centre of the peninsula, with limestone and some calcareous shale (particularly around Sutton) predominating in the north-west. The overlying soils are described as being "*Shallow well drained mineral (mainly acidic)*" soils across much of the south and east of the study area, along with some deeper areas of till (also derived from acidic substrates) along the southern margins of the peninsula (EPA, 2020). Soils in these acidic bedrock areas are mostly thin, acidic and have a very low nutrient status. They also has poor moisture retention capability. Soils derived from these rocks are a simple blend of fine fragments of weathered bedrock sheared from the bedrock and peaty podzols, derived from the accumulation of organic matter arising from the cyclical degradation of vegetation at the surface. Organic matter that gets washed into topographical depressions and valley floors means that soil depth is greater in these localised areas.

Quaternary glacial deposits also influence the soils and environment of Howth Head. Howth was covered in an ice sheet during the last Ice Age. During the glacial retreat approximately 14,000 years ago the ice and meltwaters scoured various small valleys which terminate at the coast. Most, but not all, of these valleys transmit the main streams that flow radially from the centre. The lower ground in Howth is overlain by superficial calcareous glacial deposits of variable thickness comprised of a boulder clay intermixed with gravel of Irish Sea origin. The southern extents of limestone till extend to cover Red Rock to the south and Nashville Road to the east. This till tends to be heavy and of low to moderate permeability and is visible at the westernend of Claremont Strand and on Burrow Beach. Limestone have been mapped around Howth Castle and across almost all of Howth village with smaller pockets at Howth allotments and Balscadden car park. Such gravelly sand layers are visible from Balcadden Road on the eastern side of the sand and gravel moraine at Tower Hill. The hard Cambrian rocks on raised ground east of the structural fault aren't prone to significant weathering so subsoils are almost entirely absent across large areas of raised ground. Where present they are mapped as a till derived from quartzites. This unit tends to be sandier in texture which gives it improved drainage characteristics. It can be clearly observed on the eastern cliff faces as having thickness up to 5 m. Howth peninsula is connected to the mainland by a post-glacial tombolo, consisting of raised marine sands and gravels resting on limestone bedrock. Lacustrine deposits are mapped in the depression occupied by the pond on Howth Golf Club. Made ground (mostly Sutton and Howth towns) occupies much of the northern and western portions of the peninsula.

Therefore, the wetland habitats in the area are influenced by the predominantly acidic nature of the bedrock and overlying soils (particularly in the centre, south and east), and by the predominantly lime-rich bedrock and overlying glacial till/soils (relatively fertile grey brown podzolics) in the north-west. Geological and soil maps are presented in the Envirologic Ltd. report in Appendix III.

3.1.2 Hydrology and Hydrogeology

The EPA database of watercourses in Ireland shows five first order streams on Howth peninsula, progressing clockwise from Sutton. Additional watercourses illustrated by Sweeney (2017) are also listed below (see Appendix III for full watercourse map).

- Bloody Stream – rises near Greenhollows cottage, flows north through Howth Demesne, outfalls at Claremont Beach;
- Offington Stream - flows north along the western side of the path which was formerly the tram line, just west of Balkill Park, Grace O'Malley and Evora Park residential streets. The outfall point is reportedly to the middle harbour. This is a dry channel for the majority of the year.
- Bogeen Stream (also known as Gray's Stream and Balscadden Stream) - rises in Thormanby Woods, flows north along Gray's Lane and culverted beneath Main Street before outfalling to Howth harbour, east of Howth Yacht Club;
- Coulcour Brook (also known as Kilrock Stream) – flows north along Cowbooter Lane, outfalls to Balscadden Bay;
- Whitewater Brook – rises in a minor valley near Ben of Howth, flows south-east passing close to The Summit and outfalls to a small beach north of Baily lighthouse;
- Balsaggart Stream – rises in the eastern part of Howth Golf Club south of Dun Hill, flows south through a working farm and an area known as 'The Cliffs';
- Carrickbrack Stream - rises between Dun Hill and Shielmartin and flows west, draining the western half of Howth Golf Club and the south-west area of Deerpark. The watercourse is culverted between Carrickbrack Road and has its outfall along the coast at Strand Road.
- Santa Sabina Stream - The Santa Sabina Stream is almost entirely culverted and flows west, draining a relatively small area of Deerpark which collects in a wetland area. The wetland consists of two ponds which outfall separately into a stormwater network through Offington residential estate, outfall to the coast opposite Santa Sabina Dominican College.

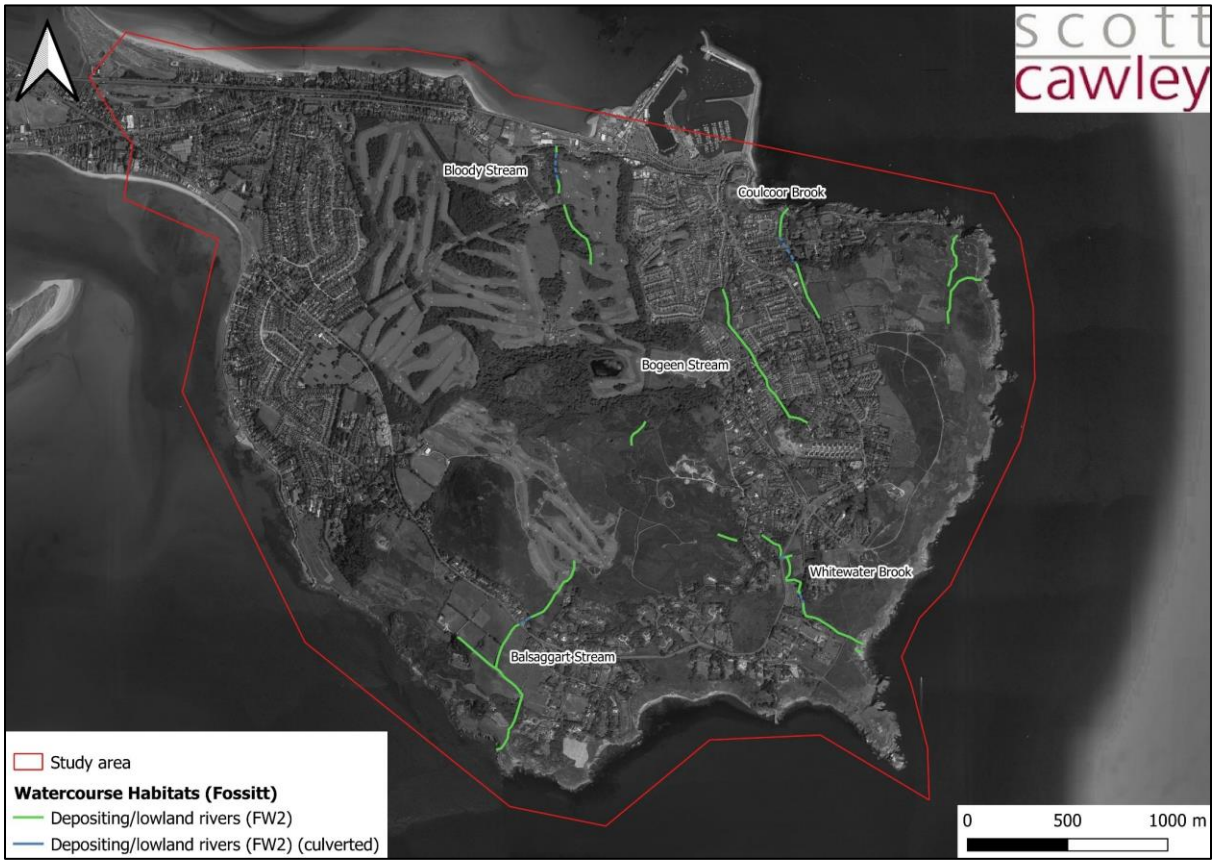
- Howth Castle Streams - a series of small, mostly culverted drainage channels that flow to the rear of Howth Castle and outfall on Claremont Beach.

Catchment sizes for these streams are limited to less than 1 km^2 and the hydrograph curve shape (i.e. how flashy the streamflow is in response to rainfall) is linked to factors such as bedrock permeability, depth of overburden and gradient.

Most of these watercourses originate on the higher altitudes of the central hills of Howth Head around the Ben of Howth, including Ben Linn, Shielmartin Hill and Carrickbrack Hill. All of these streams discharge directly into either Dublin Bay or the Irish Sea. Many of the streams are culverted in most or part of their courses. The study area is part of the Mayne sub-catchment of the wider Liffey and Dublin Bay water catchment (EPA, 2020).

Perhaps not surprisingly the Cambrian rocks have been classified by the GSI as a poor aquifer which is generally unproductive except for local zones. Poorly productive aquifers are characterised by very low permeabilities and transmissivities and are therefore low yielding. Consequently, groundwater movement within this bedrock is relatively low and is often restricted to shallow flow paths near the surface or along fracture zones. Well and spring yields within this aquifer class are typically low. Given the lack of protective overburden the Cambrian rocks in Howth are considered to be vulnerable to contamination (E/X). The massive unbedded limestones can return slightly higher yields and as such are regarded as a locally important aquifer, being moderately productive only in local zones. The general lack of bedding and jointing in Waulsortian bedrock means groundwater flows within are limited to fracture zones. Groundwater vulnerability classification across the limestone areas is typically High (H). There is little detail regarding groundwater abstractions on Howth. The GSI database contains records of shallow wells at St Fintan's (holy well) and Balsaggart. These wells are mapped close to the primary fault line and the presence of broken rocks (breccia) along the faultline caused by tectonic movement may be a primary groundwater flow path. At a local level there are reportedly domestic wells with moderate yields on Burrow Road and close to the southern coastline.

Figure 2 Map of five main first order watercourses (EPA) within the study area.



3.2 Areas Designated for Nature Conservation

3.2.1 European Sites[6]

A large portion of the centre, as well as the eastern and southern terrestrial edges of the study area are currently designated as the Howth Head Special Area of Conservation (SAC) [000202]. Furthermore, there are three other SACs which occur on the coasts of Howth Head directly adjacent to the study area. These are Baldoyle Bay SAC [000199], Rockabill to Dalkey Island SAC [003000] and North Dublin Bay SAC [000206] (see Figure 3).

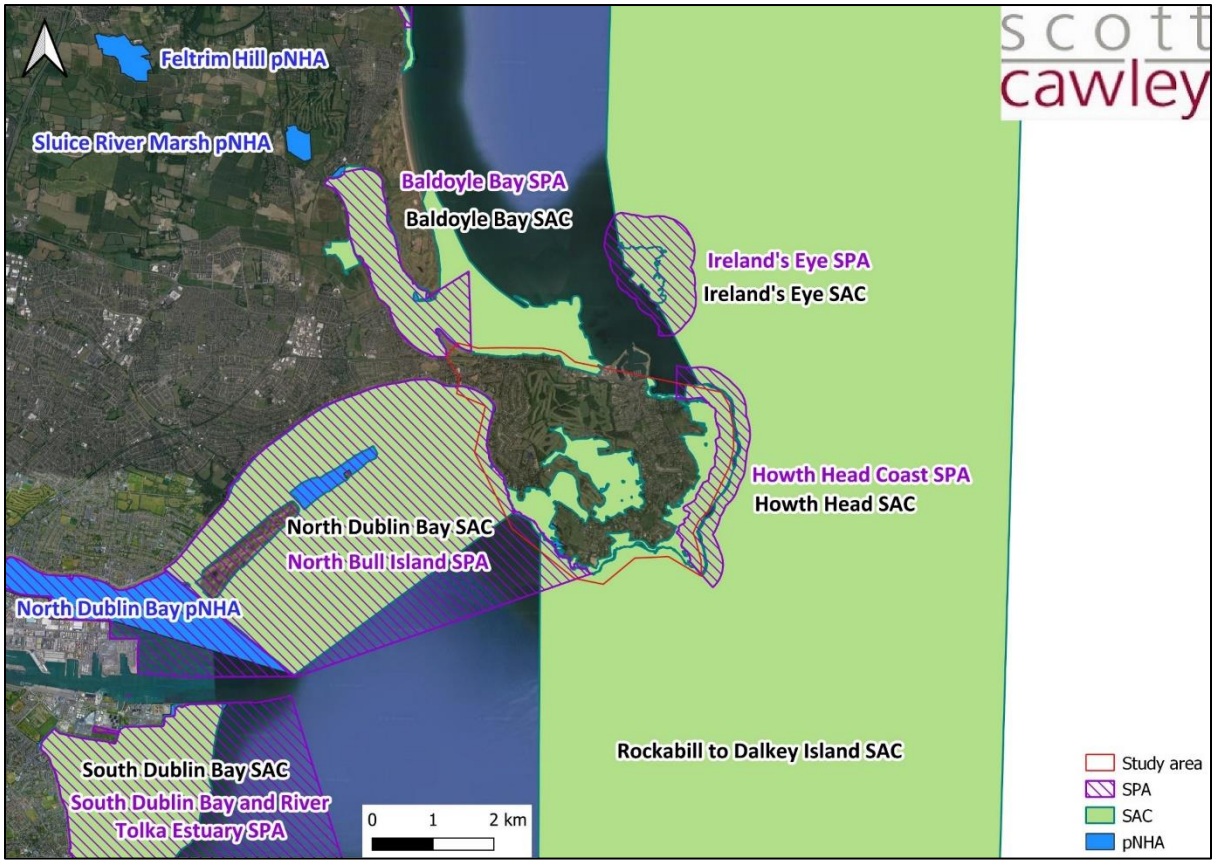
Howth Head SAC is designated for the following Qualifying Interest Annex I habitats (as per NPWS, 2016):

- 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts
- 4030 European dry heaths

Although this SAC contains a considerable number of wetland habitats and sites, it has not been specifically designated for any wetland habitats. Similarly, the Howth Head Coast SPA is designated for the Qualifying Interest Annex II bird species Kittiwake (*Rissa tridactyla*).

Figure 3 European sites and proposed Natural Heritage Areas (pNHAs) located within the vicinity of the study area

[6] The Natura 2000 network of sites are defined under the Habitats Directive (Article 3) as a European ecological network of special areas of conservation, composed of sites hosting the natural habitat types listed in Annex I and species listed in Annex II, and special protection areas classified pursuant to the Birds Directive (2009/147/EC). The aim of the network is to aid the long-term survival of Europe's most valuable and threatened species and habitats. In Ireland, these sites are designed as *European sites* – as defined under the Planning and Development Acts and/or Birds and Habitats Regulations as (a) a candidate site of Community importance, (b) a site of Community importance, (c) a candidate special area of conservation, (d) a special area of conservation, (e) a candidate special protection area, or (f) a special protection area. They are commonly referred to in Ireland as candidate Special Areas of Conservation (cSACs) and Special Protection Areas (SPAs).



3.2.2 Proposed Natural Heritage Areas and Natural Heritage Areas

Natural Heritage Areas (NHA) and proposed Natural Heritage Areas (pNHA) are nationally designated sites which give protection to sites of natural importance within the Republic of Ireland. Howth Head pNHA is the only pNHA that occurs within the study area, and it is protected for the same reasons as the above SAC and SPA(see Figure 3). No NHAs occur within or near to the study area.

3.3 Other Sources of Protection on Howth Head

Fingal County Council created the Howth Special Amenity Area Order (SAAO) in 1999 (the Order was brought into law by the Minister for Marine and Natural Resources on 16th May 2000), recognising the special heritage, historic and natural characters of Howth Head. This Order not only protects and preserves many of these unique local features, but also aims to enhance these features, through the actions of the Howth SAAO committee. This committee has developed and encouraged many ecological research and restoration projects on Howth Head since its establishment, including the current wetlands project, alongside Fingal County Council. The *SAAO Operational Plan 2015-2020* includes a specific objective for wetlands:

- Action 1A. 1.1 – Map former and existing waterbodies (wetlands, springs, streams etc) and make comparison with historical data and maps.

3.4 Wetland Habitats on Howth Head

3.4.1 Desk Study Results

The following 14 sites were located following the desktop study of all available online resources, aerial images and discussions with local experts. These sites were all later ground-truthed during the initial stages of the fieldwork. All but two (namely, site 13 Flush at Balscadden Beach and site 14 Redrock) of the sites were subsequently included for detailed surveys. These two sites were excluded due to their very limited size and/or quality of existing wetland habitat. Furthermore, a former tufa spring site ([7220] Petrifying

springs with tufa formation (*Cratoneurion*)) on a bank by Balscadden Road (at Irish Grid reference O29240 39030) was mostly destroyed in the last 10 years as it was backfilled by soil as part of the construction of the retaining wall located on the bank by the roadway (Melinda Lyons, pers. comm., February 2021).

Table 1 Table of 14 wetland sites which were located as a result of the desktop study.

Site Code	Site Name
1	Thormanby Woods
2	Greenhollows
3	Bog of Frogs
4	Whitewater Brook
5	Kilrock Quarries
6	Coulcoor Brook
7	Bogeen Stream
8	Offington Wetland
9	Balsaggart Stream
10	Bloody Stream Catchment
11	Nose of Howth
12	Sutton Golf Club Ponds
13	Flushes and springs at Balscadden Road and Balscadden Beach
14	Redrock

Doogue (2009) began his discussion of existing wetland habitats on Howth Head by pointing out how stark the rate of loss of such habitats has been in the area since the time of H.C. Hart's '*Flora of Howth*' (Hart 1887). Hart regularly referred to various substantial wetlands, of which there is now no known trace:

> "*The most serious single-site loss appears to have been in the area around Greenfields* [in northwest Howth Head] *where he* [Hart] *recorded many plants from what he described as a bog near the shore. Losses here include Water Speedwell, Veronica anagallis –aquatica which Hart recorded from "Deep ditches about Greenfields and in a boggy hole between that and Sutton". There were many other quarries in the lower parts of Howth, many of which have been filled in with considerable damage to the native flora. He also discovered a group of species that would be more typical of good-quality lime-rich fenny conditions including Grass of Parnassus, Parnassia palustris and few-flowered Spike-rush, Eleocharis quinqueflora, both in a marsh "near the summit of Howth". Many efforts have failed to re-find these species although the site still has a limited wetland flora. There were several ponds in Quarry townland, most of which are filled in. Losses here and at the nearby Corr Castle included water buttercups which have become much rarer in modern Ireland.*"

The wetland habitats of today's Howth Head are remarkably different from that which was present over a century ago. Nonetheless, a number of varied wetland sites have persisted to the present day in the area. These habitats include wet grasslands, wet disused quarries and smaller quarry pits, wet woodlands, flushes, streams, ponds, swamps and reservoirs.

3.4.2 Field Survey Results

The Fossitt (2000) habitat types recorded on Howth Head during the surveys are as follows:

- Wet willow-alder-ash woodland (WN6) – limited to Gray's Wood (site 1), this is one of the most rare and threatened habitat types on Howth Head currently;
- Wet grassland (GS4) – this is the most widespread and common habitat on Howth Head currently;

- Lagoons and saline lakes (CW1) – this habitat is limited to one pond in Sutton Golf Club (site 12), which is influenced by brackish water influx (note that salt-marsh wetlands were generally not assessed during this survey);
- Reservoirs (FL7) – this habitat is represented by one of the largest wetland habitats on Howth, namely, Howth Reservoir (part of site 10);
- Other artificial lakes and ponds (FL8) – ponds are common wetland features on Howth Head, with 14 individual pond polygons (often combined with other habitats) noted during the present survey;
- Reed and large sedge swamps (FS1) – this habitat occurs in association with many of the above-mentioned pond habitats on Howth Head;
- Tall-herb swamps (FS2) – this habitat was located in both the Gray's Wood (site 1) site and in Black Jack's Pond in site 10;
- Rich fen and flush (PF1) – limited to the Kilrock Quarries (site 5) and Offington Wetland (site 8) sites; a further small area of base-rich flushing occurs at Balscadden Beach (however, this habitat was not assessed in detail as a separate site – see Table 1 above). An overview map of the locations of these habitat types is presented in Figure 4 below, while more detailed maps are provided for each site in section 4 below.
- Calcareous springs (FP1) – limited to one tufa-forming spring on Balscadden beach (Site 13).

Wet grassland, followed by artificial ponds, are the most common habitats to be found in wetland sites on Howth Head. Fens, bogs, flushes and marshes have become increasingly rare wetland features on Howth (no true bog or marsh vegetation was recorded during the surveys), which is in stark contrast to the situation during Hart's surveys in the late 1800s, and indicates a general drying out of the area (*i.e.* due to increased drainage and lowering of the water table, *etc.*), along with the active removal of natural wetland habitat by human interference and their replacement with artificial pond features, particularly in the various golf courses which occur on the peninsula (*e.g.* the Howth Golf Club pond, which was the site of an old natural lough wetland in historic maps – see site 9 for more information).

Out of the 14 ground-truthed sites (see Table 1), 12 in total were selected for more detailed botanical and hydrological surveys (based on an assessment of the relative ecological importance of the different sites). These 12 core wetland sites on Howth Head have been ranked according to their levels of considered botanical importance (see Table 2), and these sites also represent the best opportunities for potential future wetland restoration and/or enhancement actions. They are each discussed in detail in section 4 (see Figure 5 for a location map of these sites), along with the Irish Vegetation Classification (IVC) communities that were found at each site and detailed recommendations for restoration and/or enhancement of these sites (the most important actions[7] being in bold type).

Table 2 12 wetland sites which are assessed in detail in section 4 below, listed according to their current ranking of botanical importance.

Site Code	Site Name	Ranking of Botanical Importance
5	Kilrock Quarries	1
8	Offington Wetland	2
1	Thormanby Woods	3
2	Greenhollows	4
4	Whitewater Brook	5
3	Bog of Frogs	6

[7] These actions were deemed to be most importance based upon the considered urgency of each action, as well as the extent of positive impact which the action would likely produce for the wetland habitats and sites concerned.

10	Bloody Stream Catchment	7
9	Balsaggart Stream	8
7	Bogeen Stream	9
11	Nose of Howth	10
6	Coulcoor Brook	11
12	Sutton Golf Club Ponds	12

The most common IVC communities found across the various sites were various wet grassland communities, including:

- *Juncus effusus – Rumex acetosa* grassland (GL2D) community;
- *Holcus lanatus – Lolium perenne* grassland (GL2C) (often wetter forms);
- *Juncus acutiflorus – Holcus lanatus* grassland (GL1A), and;
- *Agrostis stolonifera – Ranunculus repens* marsh-grassland (GL2A)

Within the stream courses, the commonest community was:

- *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E)

Three of the detailed study wetland sites on Howth Head conform to the following Annex I habitats:

- Heavily degraded [*91E0] Alluvial forest with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-padion, Alnion incanae, Salicion albae) – this degraded wet woodland occurs in Gray's Wood (Site 1 – see section 4), and,
- [7230] Alkaline fens – occurs within the Kilrock Quarries (Site 5 – see section 4) site (NPWS, 2019), which has base-rich flushing. The Offington Wetland (Site 8 – see section 4) also conforms to the Annex I habitat [7230] Alkaline fens, primarily due to the presence of the high quality indicator species *Epipactis palustris* (Marsh Helleborine) here (NPWS, 2019).

Figure 4 ***All known existing wetland habitats, as per Fossitt (2000), recorded in the study area during the present 2020 surveys.***

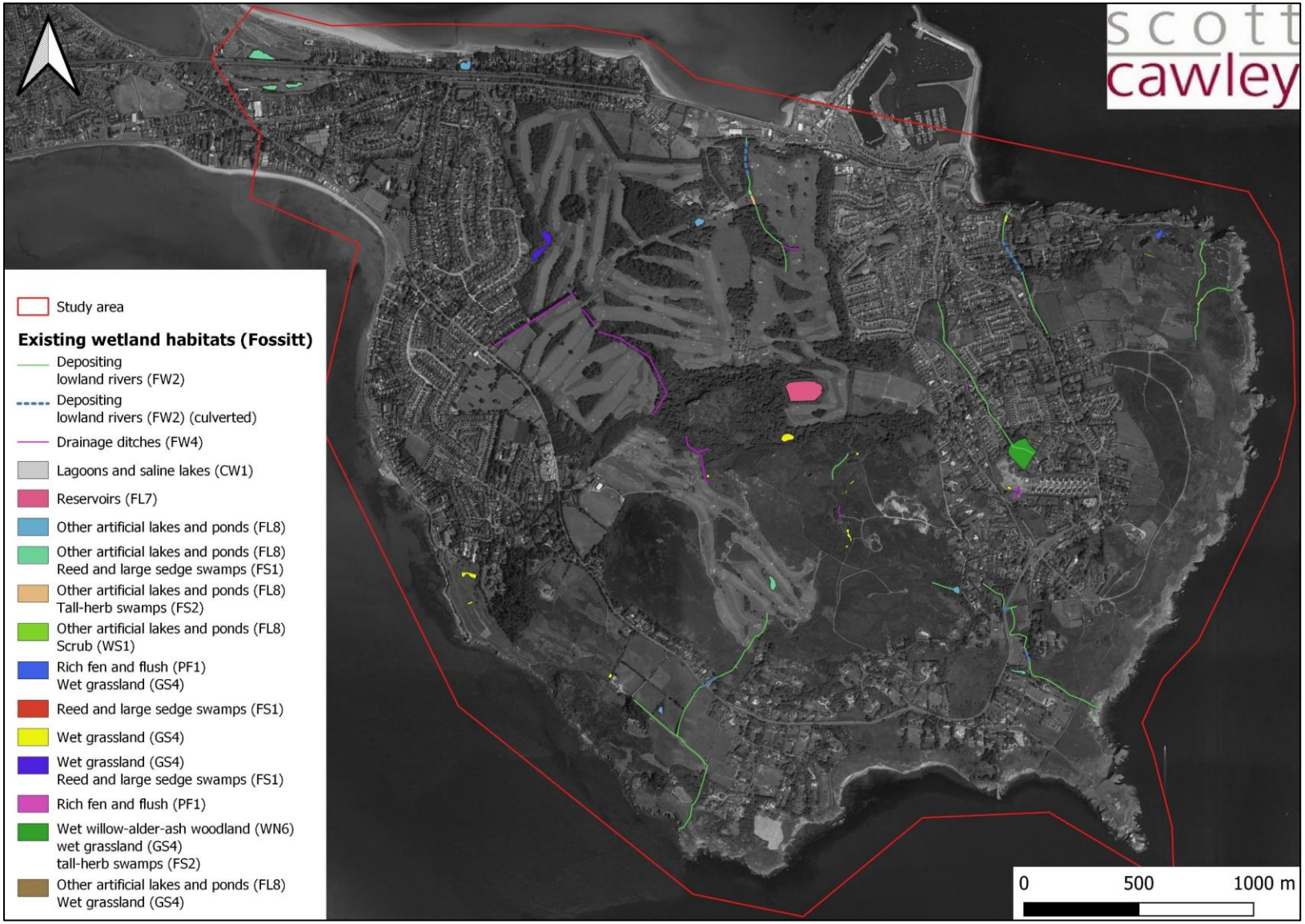


Figure 5 Locations of all 12 core sites recorded during the present 2020 surveys.

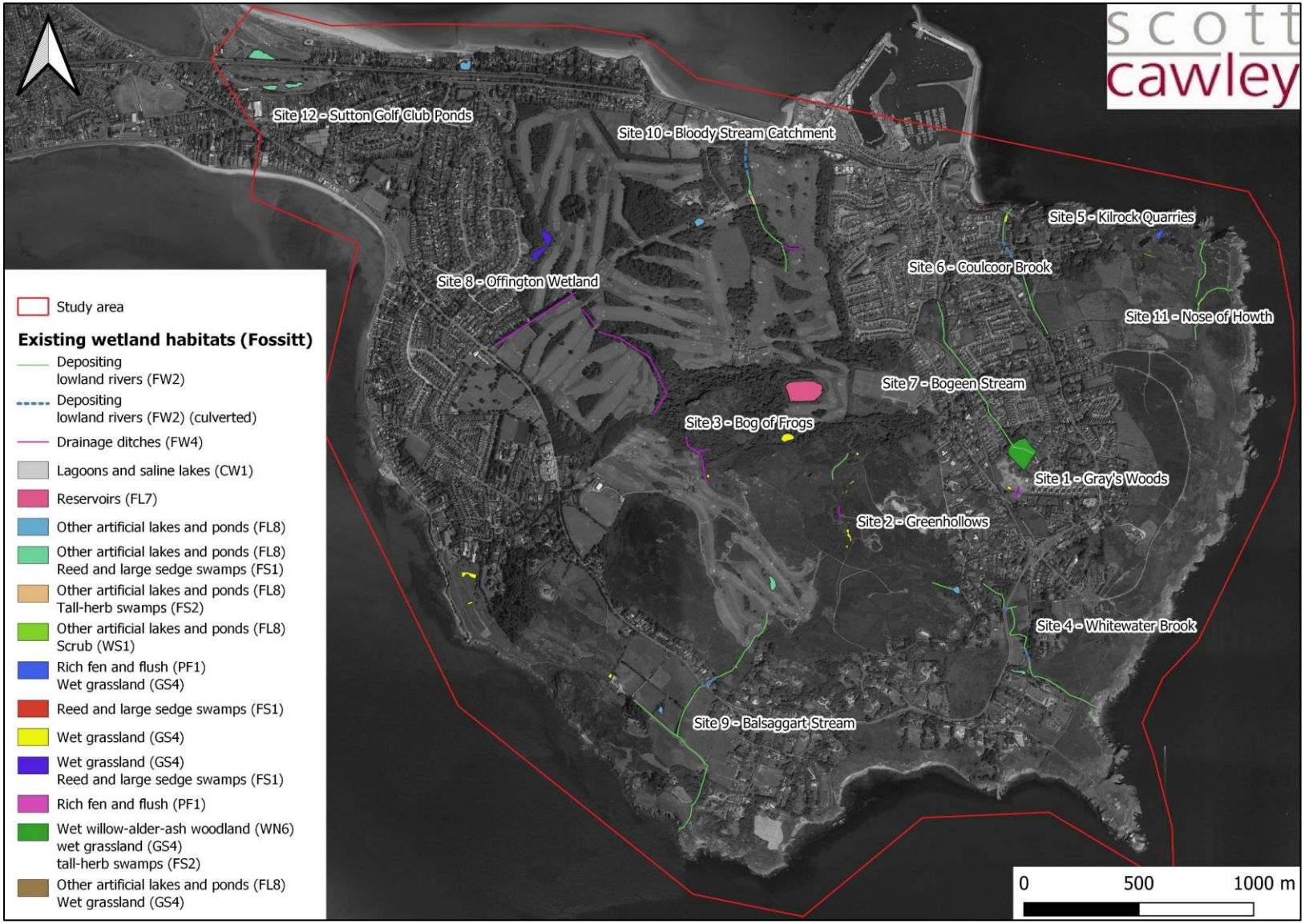
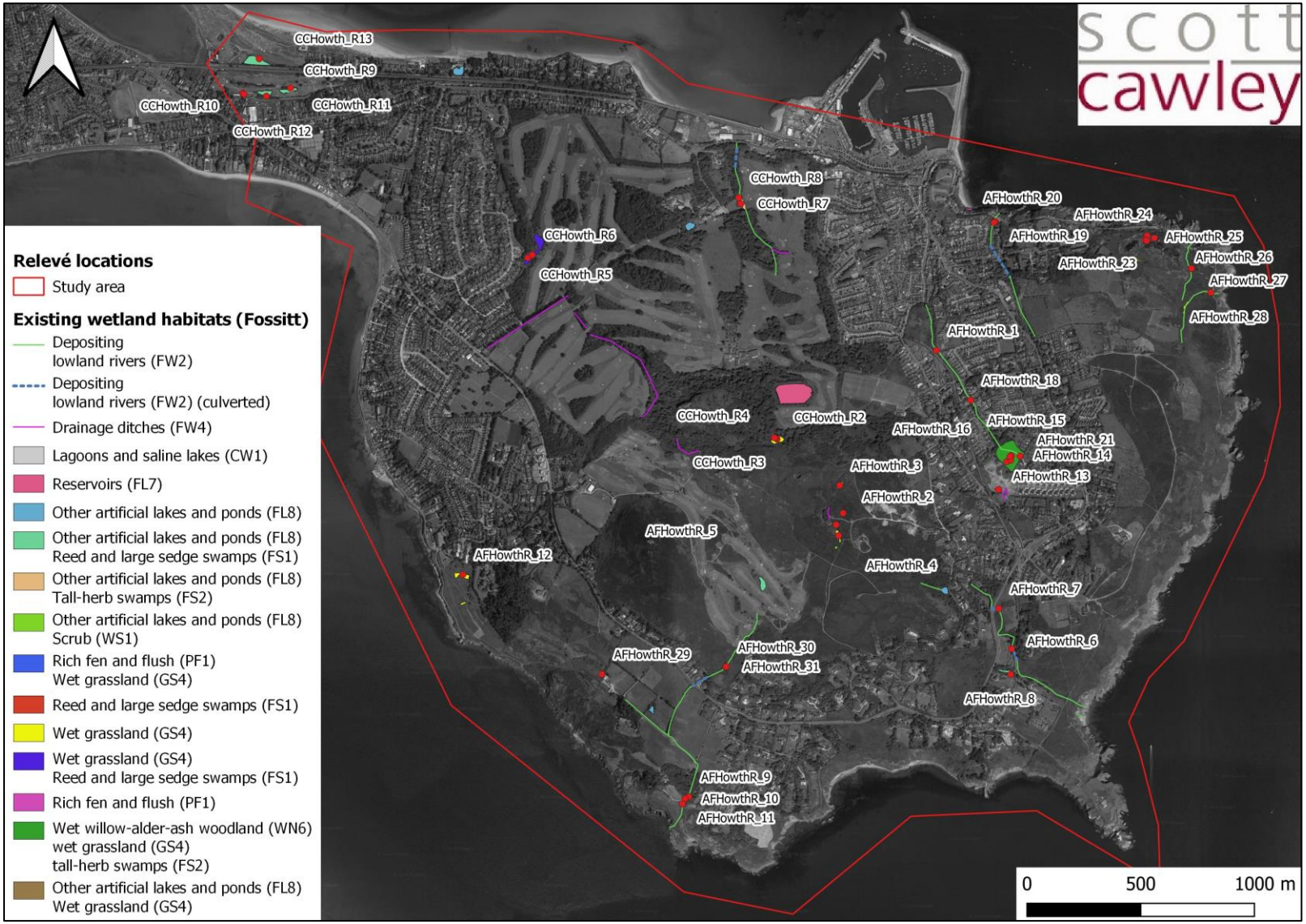


Figure 6 Locations of all 44 vegetation relevés recorded across the study area during the present 2020 surveys.



3.5 Notable Wetland Flora on Howth Head

3.5.1 Desk Study Results

The first known botanist to record wild plants on Howth Head was Caleb Threlkeld, who produced Ireland's first ever flora, '*Synopsis Stirpium Hibernicarum*', in 1726 (Threlkeld, 1726). Walter Wade was another early Irish botanist to survey plants on Howth. He published his '*Catalogus systematicus Plantarum indigenarum in Comitatu Dublinensi inventarum*' in 1794 (Wade, 1794). He was one of the first botanists to record wetland plant species on Howth. He noted such interesting species as *Eleogiton fluitans* (Floating Club-rush), which he found "*In the marshy ground at Howth*" (Doogue, 2009). This species was re-found on numerous occasions on wet acidic ground in the higher hills and streams of Howth, including in wet quarries pools in the Greenhollows area (site 2 – see section 4) as recently as 1990 (Doogue *et al.,* 1998). This species is very rare in Dublin; this was the only known surviving site for this species in the county (Doogue *et al.,* 1998). However, in the Republic of Ireland, it is listed as being of Least Concern (LC) (Wyse Jackson *et al.,* 2016).

The next notable botanist to survey the plants (including wetland species) of Howth Head in detail was H.C. Hart, who published the first '*Flora of Howth'* in 1887 (Hart, 1887)[8]. This flora included records of a number of notable Dublin wetland plant species, such as *Eleocharis quinqueflora* (Few-flowered Spike-rush), which he noted "*In two places in the marsh near the summit of Howth*". He also noted *Parnassia palustris* (Grass-of-Parnassus) in this same marshy area. Neither of these species have been re-found in the area in recent decades. The apparent loss of these base-rich marsh indicator species is indicative of the kinds of losses of wetland habitat that have been incurred in the area over the last few centuries and decades, likely driven by both man-made and natural influences. Both species are rare in Co. Dublin (Doogue *et al.,* 1998), however, in the Republic of Ireland, they are listed as being of Least Concern (LC) (Wyse Jackson *et al.,* 2016). Another notable wetland species recorded by Hart (1887) was *Myriophyllum alterniflorum* (Alternate Water-milfoil), which he noted in "*quarry ponds between Howth and Baldoyle Stations*". This species was not re-found during the present 2020 surveys in these areas, as these quarry pond habitats were almost certainly removed for developments in the proceeding decades (particularly in the area which was referred to as "*Greenfields*" – in northwest Howth Head). This is a frequent habitat on Howth which was quoted by Hart and other early botanists as containing important wetland species and habitats, but which has in many cases now been removed entirely, with the notable exception of the Kilrock Quarries (site 5) and Greenhollows (site 2) sites (see section 4 for more details).

A few notable wetland bryophyte species have been recorded on Howth Head over the years. T. Taylor recorded the fen species *Scorpidium scorpioides* from Howth between 1816 and 1836, and in 1865, F.W. Hutton recorded the common bog species *Sphagnum cuspidatum* from Howth (Denyer & Hodd, 2019). Later, McArdle (1893a) recorded a notable wetland *Scapania* species, namely *Scapania undulata*, which is generally found in streams or rivers (Atherton *et al.*, 2010).

Denyer & Hodd (2019) have completed the most recent detailed survey of bryophytes on Howth Head. Their survey uncovered a new site for the rare Dublin fen moss *Campyliadelphus elodes,* at Kilrock Quarries (site 5 – see section 4.7); this being the first record for this species from Howth Head and the first record of this species for Co. Dublin since 1852. They also recorded *Scapania undulata*; the first record for this species on Howth since McArdle's 1893 report of the species.

[8] A second edition of Hart's (1887) flora is currently being compiled by Botanical Society of Britain and Ireland (BSBI) vice-county recorder for Kildare, Declan Doogue, and BSBI vice-county recorder for Dublin, David Nash, along with other members of the Dublin Naturalists' Field Club.

3.5.2 Field Survey Results

During the present 2020 surveys, five wetland plant species of importance within the context of Howth Head and/or Co. Dublin were recorded and all of these are mapped in Figure 6 below, *i.e.*:

- A small population of the rare Dublin orchid *Epipactis palustris* (Marsh Helleborine) was recorded in the Offington Wetland site (site 8) at the western margin of Deer Park golf course (see section 4). This population was previously referenced by Doogue (2009), and is probably a recent arrival in this area, perhaps via wind-borne seeds from the much larger populations on North Bull Island. This is a very significant Howth plant population which is very important to conserve and protect. In the Republic of Ireland more broadly, this species is listed as being of Least Concern (LC) (Wyse Jackson *et al.,* 2016).
- *Equisetum variegatum* (Variegated Horsetail) and *Samolus valerandi* (Brookweed) were both recorded from Kilrock Quarries (see section 4). *Samolus valerandi* was also recorded from the south shore of the northern most pond in Sutton Golf Club (site 12 – see section 4) on 21st August 2020, a re-find of Hart's record of this species from "*wet or damp places, chiefly by the sea…Sutton*" (Hart 1887). *Equisetum variegatum* is a "*very rare*" species in Co. Dublin, whilst *Samolus valerandi* is occasional in coastal wetlands (but rare inland) (Doogue *et al.,* 1998). Both species are well-known by local botanists at the Kilrock Quarries site (Doogue *et al.* 1998; Declan Doogue, pers. comm., September 2020). In the Republic of Ireland more broadly, these species are both listed as being of Least Concern (LC) (Wyse Jackson *et al.,* 2016).
- An unconfirmed record of the very rare Irish hybrid (BSBI, 2020) *Epilobium* × *rivulare* (*Epilobium parviflorum* × *E. palustre*) was noted at a ditch with wet grassland vegetation alongside both its parents, located at the southern margin of Deer Park golf course on 19th August 2020, however, there was insufficient mature fruiting material on the plant to confirm hybrid sterility[9]. This record requires confirmation in the future.
- The rare aquatic bryophyte species *Drepanocladus aduncus* was discovered at an old wet quarry pit at Greenhollows (site 2 – see section 4). This is the second record for this bryophyte species from Howth, the first record having been made by David Holyoak at Kilrock Quarries (site 5 – see section 4) in 2007 (Melinda Lyons, pers. comm., September 2020). This species is widespread but infrequent in Ireland more broadly (Blockeel *et al.,* 2014).

[9] Fruiting material is best collected in late September/October.

Figure 7 Notable vascular plant and bryophyte species recorded on Howth Head during the present 2020 surveys.

Plate 1 Epipactis palustris (Marsh Helleborine) in fruit in the Offington Wetland site (Site 8).

Plate 2 Samolus valerandi (Brookweed) by the southern edge of a pond at Sutton Golf Club (Site 12).

Plate 3 Depiction of Drepanocladus aduncus[10]

[10] Sourced from http://www.freenatureimages.eu/ - image produced by Jan van de Wiel.

4 Wetland Site Reports

4.1 Site 1 – Gray's Wood

4.1.1 Overview

Gray's Wood is a spring-fed wet woodland site which occurs at Thormanby Hill in the east of Howth Head. This site has been subject to damage and drainage related to local housing developments at the Thormanby Hill development site. Prior to development, the woods were most likely fed by groundwater seeps and springs (mostly on the slopes located directly south and east of the wood), either directly to the root zone, as shallow groundwater, or emerging to the surface before flowing the short distance overland into the woods.

In Hart's (1887) Howth Head map, this woodland is present as a substantial isolated area of woodland, surrounded by fields, with the Bogeen Stream (see site 7) flowing through the centre of the woodland and rising on the slope located directly south-east of the woodland. Furthermore, in the historic 25 inch maps from 1888-1913, a spring is indicated just south of the woodland boundary, with discharge carried to the primary watercourse via a short northbound channel. Historical maps also show a spring on higher ground on the southern side of the Kitestown Road.

A management plan for the site was introduced in 2016 and vegetation monitoring work has been conducted at the site by Scott Cawley Ltd. and Denyer Ecology since 2017 (Scott Cawley, 2017; Denyer 2018). This site is currently ranked as the third most important botanical wetland site on Howth Head due to the presence of an EU Habitats Directive Annex I wetland habitat within the site (see Table 2).

4.1.2 Hydrology

This woodland occurs in a naturally enclosed depression at the foot of a short, south-eastern to north-western valley, which forms the headwaters of the Bogeen (or Balscadden) Stream. Due to the presence of the Thormanby Hill development site, there now exists a large cutaway from the north-facing embankment located south of the woodland. The exposed material is mostly constituted of glacial till and a transition zone into weathered rock approaching composite bedrock. There are numerous seepages and small discrete spring outflows from the transition zone. These are all captured, channelised and diverted towards a temporary culvert inlet located beneath the internal haulage road in the development site. The culvert consists of a single 200 mm pipe. The outfall of this pipe was not located during the present survey; however it is considered likely that it outfalls into Bogeen Stream in the woods. The Bogeen Stream originates directly south-east of this woodland and flows straight through its centre in an east-west direction.

There is also an area of significant ponding in the eastern section of the woodland. The source of this water is unclear; however, it may be representative of the pre-development hydrological regime, or it may be shallow groundwater rising to the surface due to flow impedance as a result of recent works. This wet area corresponds with the tall-herb swamps (FS2) habitat outlined below.

Prior to development, the woods were most likely fed by these groundwater seeps and springs (mostly on the slopes located south and east of the wood), either directly to the root zone, as shallow groundwater, or emerging to the surface at previous toeslope before flowing the short distance overland into the woods (indeed the aforementioned vegetation monitoring reports completed at the site support the evaluation of the site as a likely spring-fed wet woodland site). The interception and channelisation of these groundwater seepsand springs currently deprives the woods of these diffuse flows and groundwater chemistry controls. In the absence of restoration measures, the woodland will likely dry out as a result, accelerated by the drainage channels in the wooded area. A report by Doogue (2009) includes a photograph of the site from before much of the drainage damage occurred here, and shows a very much intact wet woodland habitat, all too different from its current condition.

4.1.3 Vegetation Description

The wetland habitats at the site are largely made up of wet grassland (GS4) in the ground layer (with a small area of tall-herb swamps (FS2)), and scattered to more dense wet willow-alder-ash woodland (WN6) canopy vegetation above. *Alnus glutinosa* (Alder) is the dominant canopy tree species at the site, and some areas of formerly cleared ground (for the development) are now exhibiting some dense *A. glutinosa* scrub re-growth.

The dominant canopy woodland IVC community within this wetland site is *Alnus glutinosa – Ranunculus repens* woodland (WL3B). This woodland community generally occurs on "*fertile, base-rich gleyed soils, but can occur on well-drained mineral soils which are subject to periodic inundation, and also as alder carr on fen peats*" (NBDC, 2020). In the case of this site, the periodic inundation is (or rather was) probably provided by base-enriched springs in the locality. One of the primary threats to this woodland community is "*changes to hydrological regimes*" and so the development-related disturbance of the hydrological dynamics of this site is a cause for great concern. This wet woodland vegetation, although heavily degraded, does still corresponds to the priority EU Habitats Directive Annex I habitat [*91E0] Alluvial forest with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-padnion, Alnion incanae, Salicion albae) albeit degarded, and restoration works, if successful, could potentially improve the quality of this priority Annex I habitat.

The main wet grassland community in the site is *Juncus effusus – Rumex acetosa* grassland (GL2D). This community is characterised by the presence of abundant and well-grown *Juncus effusus* (Soft Rush), along with the frequent presence of such species as *Ranunculus repens* (Creeping Buttercup) and *Rumex acetosa* (Common Sorrel). This is a generally species-poor grassland community which is of low considered conservation value (NBDC, 2020).

In the more inundated areas of the site, a separate swamp community can be found, namely *Equisetum fluviatile – Eleocharis palustris* swamp (FW3G). Four sub-communities are tentatively described for this community in NBDC (2020), however, there was no statistically significant relationship to any of these according to the ERICA statistical analysis output, although perhaps the *Equisetum fluviatile* sub-community (FW3Giv) is most applicable as there are no frequent associates (NBDC, 2020). The FW3G community is a generally species-poor community which is of "*relatively low recognised conservation value*" (NBDC, 2020). One of the primary threats to this community is drainage, and this again reinforces the importance of conserving the hydrological dynamics in the area as part of restoring and conserving this wetland site.

The section of Bogeen Stream which occurs within the site is dealt with separately in the Site 9 account below. However, relevant to Site 1, Denyer (2018) noted the occurrence of the charophyte *Chara vulgaris* in this stream in 2018 (referred to as a "*drainage channel*" in that report), which suggests that this area encompasses Site 1 is "*influenced by calcareous spring water*". *Chara vulgaris* was not found in the stream/channel during the present 2020 surveys, which may indicate a reduction of spring influence in the area in recent years, or perhaps just natural vegetation succession.

A further small patch of *Juncus effusus – Rumex acetosa* grassland (GL2D) occurs south of the wet woodland in an open area of the adjacent development site, alongside a drainage ditch (FW4) (see Figure 4). This is a generally species-poor grassland community which is of low considered conservation value, according to NBDC (2020).

4.1.4 Threats and pressures

This site has been subject to vegetation clearance and significant drainage works related to the recent construction of local housing developments at the Thormanby Hill development site. Construction activities associated with these developments have caused a severe reduction to the groundwater seepage and spring water which used to maintain this wet woodland. As a result, this site is increasingly drying out and becoming encroached by scrubland.

4.1.5 Recommendations

1. **Rewetting of the site could be aided by the installation of a sluice gate in the Bogeen Stream drainage channel located within the woodland to allow for the re-flooding the wet woodland on occasion. Whilst this may not reverse the aforementioned drying out process, it could be potentially beneficial for the wet woodland in the vicinity of the stream and is the only likely feasible option to trial. However, Envirologic (2020) considers this proposal to be less desirable as it may lead to "*permanent waterlogging*".**
2. **Attempts could be made to mimic the old spring-fed hydrogeological regime by trying to re-distribute the channelised flow upgradient of the woods into a more diffuse pattern; however this is also logistically difficult. More knowledge about the pre-development regime in the future with regards to groundwater levels, flows, chemistry is required to inform the suitability of this recommendation.**
3. Given the uncertainty on when construction will resume in the adjacent development site, some interim measures could be implemented. This would include installing headwork to house the current 200 mm culvert.
4. Sedimental control measures to treat groundwater and runoff flowing across the construction compound and into the woods is essential.
5. **Detailed mapping of the current drainage infrastructure across the site is required. This would include confirmation of the outlet point of the 200 mm culvert and the potential source of ponding in the eastern half of the woodlands.**
6. Long-term monitoring of groundwater levels and quality on the embankment and within the woods could be facilitated by installation of piezometers. This should be considered to establish a baseline of water quality prior to further construction.
7. Removal of made ground at the south-western edge of the fenced off wet woodland site would also help to access the water table and potentially allow for the expansion of habitat.
8. An undeveloped buffer zone has been recently installed around the spring area located south of the woodland. This should be retained in place.
9. Intermittent *Rubus fruticosus* agg. (Bramble) scrub removal in drier parts of the wet woodland should be considered. Physical removal should occur in winter. Herbicides should not be used and all cuttings should be removed from the site.

Figure 8 Gray's Wood (Site 1) map.

Plate 4 Alnus glutinosa (Alder) re-growth in formerly cleared ground in Site 1; older surviving Alnus glutinosa trees can be seen in the background.

Plate 5 Relevé AFHowthR_13 in Site 1: Juncus effusus – Rumex acetosa grassland (GL2D).

Plate 6 Relevé AFHowthR_16 in Site 1: Alnus glutinosa – Ranunculus repens woodland (WL3B), with dense Juncus effusus in the ground layer of the woodland.

Plate 7 Relevé AFHowthR_14 in Site 1: Equisetum fluviatile – Eleocharis palustris swamp (FW3G).

4.2 Site 2 – Greenhollows

4.2.1 Overview

Greenhollows occurs on higher ground located directly west of the active Greenhollows quarry, in the centre of Howth Head. It is located near Ben Linn, the highest summit of Howth Head. Being on higher ground, this site is predominantly acidic in nature and indeed much of the area is dominated by acidic heathland, scrubland and old quarry pits. However, some water sources and wetland habitats do occur in this area. This site is currently ranked as the fourth most important botanical wetland site on Howth Head due to the presence of a rare Dublin bryophyte, *Drepanocladus aduncus,* and the historic presence of a rare Dublin wetland vascular plant, *Eleogiton fluitans* (see below)(see Table 2).

4.2.2 Hydrology

The higher altitudes at this site lead to higher rainfall levels in the vicinity, and therefore, a number of Howth streams originate in this general area, including Whitewater Brook (site 4). Furthermore, the old quarry pits in this area are filled with pools of water in which wetland vegetation has formed. There are also two artificial ponds in this area, including the pond adjacent to a residence (Greenhollows Cottage), which is of uncertain origin, but may have been constructed in recent years. The water level of this pond is likely to be controlled by a bedrock fracture, with water leaking to a 3-6m deep horseshoe shaped depression 10m to the north-east. The water from the Greenhollows site ultimately drains in a northerly direction towards the Howth Reservoir.

4.2.3 Vegetation Description

Many of the wetland habitats in the area consist of old quarry pits with wet pools and wetland vegetation developed within them. Within these habitats, wet grassland (GS4) is the most common habitat, and specifically, the community *Juncus effusus – Rumex acetosa* grassland (GL2D). This community is characterised by the presence of abundant and well-grown *Juncus effusus* (Soft Rush), along with the frequent presence of such species as *Ranunculus repens* (Creeping Buttercup). In the northernmost quarry pool, known as 'Goat Pond', an unusual mosaic-like assemblage of species was found with *Molinia caerulea* (Purple Moor-grass) and *Juncus effusus* (Soft Rush) being dominant, along with a significant population of the rare aquatic moss *Drepanocladus aduncus* on rocks in the flooded base of the pit. This artificially created community is rather unusual in character. There was no statistically significant relationship between this assemblage of species and any wetland community, according to the ERICA statistical analysis output. It has affinities to *Molinia caerulea – Potentilla erecta – Agrostis stolonifera* grassland (GL1D) (due to the significant presence of *Molinia caerulea*), *Schoenus nigricans – Campylium stellatum* fen (FE1A) (due to the significant presence of *Molinia caerulea* and *Drepanocladus aduncus)* and more standard *Juncus effusus – Rumex acetosa* grassland (GL2D) (due to the significant presence of *Juncus effusus*). *Eleogiton fluitans* (Floating Club-rush) is an important wetland species which was recorded in one of these local wet quarry pits in past decades; however, it has not been seen here since 1990 (Doogue *et al.* 1998). This species is likely to be locally extinct here now as a result of the quarry pit where it was found being filled with organic sediment and partially dried out (see Figure 9 for its historic location). However, *Polytrichum commune* still occurs in this pit.

Two artificial ponds occur at this site, the first of which is a small pond located directly east of a residence (Greenhollows Cottage). The pond has little or no aquatic plant vegetation and is largely made up of clear open water. Scrub (WS1) surrounds the pond on most sides, except for the south-western side, which is dominated by a *Phragmites australis – Equisetum fluviatile* swamp (FW3E) community. Not surprisingly, this community is dominated by *Phragmites australis* (Common Reed) beds and it usually surrounds lakes, ponds or lagoons. Another artificial pond occurs under a dense area of scrub (WS1), but is very species-poor and again largely consists of open water, with no fringing wetland vegetation to be seen.

Another unusual wet grassland assemblage occurs directly south of this residential pond, in an area that has been recently cleared of invasives including *Rhododendron ponticum* (Rhododendron) and therefore is quite disturbed. *Juncus conglomeratus* (Compact Rush), *Agrostis stolonifera* (Creeping Bent) and *Juncus acutiflorus* (Sharp-flowered Rush) are all frequent. There was no statistically significant relationship between this assemblage of species and any wetland community, according to the ERICA statistical analysis output. This assemblage has affinities with both *Juncus acutiflorus – Holcus lanatus* grassland (GL1A) and *Agrostis stolonifera – Ranunculus repens* marsh-grassland (GL2A); however, *Juncus conglomeratus* is more frequent here than in either of these individual communities.

The drainage ditch (FW4) to the north-west of the residential pond has almost no water and no wetland vegetation within it. This drainage ditch then links up with a water channel to the north which flows towards Howth Reservoir. No wetland vegetation was observed in the drainage ditch.

Finally, near this stream, just north of the walking path which leads to the Bog of Frogs, another small but interesting area of wetland vegetation occurs, which has recently become invaded by large quantities of *Rhododendron ponticum* (Rhododendron). *Molinia caerulea* (Purple Moor-grass)*, Narthecium ossifragum* (Bog Asphodel), *Juncus acutiflorus* (Sharp-flowered Rush), *Deschampsia cespitosa* (Tufted Hair-grass), *Sphagnum papillosum, S. palustre and S. capillifolium* are all frequent here. This area probably formerly represented true bog/flush habitat in the past, but is now drying out and becoming invaded by invasive species and scrub and as such has reverted to wet grassland (GS4) with some former bog/flush species indicators (particularly the *N. ossifragum* and *Sphagnum* species).

4.2.4 Threats and pressures

Scrub encroachment (especially in the vicinity of the two ponds in the site) and the spread of invasive species in these habitats are primary threats. In particular, the invasive species *Rhododendron ponticum* (Rhododendron) is known to occur in this site. This species is listed on the Third Schedule of the *European Communities (Birds and Natural Habitats) Regulations* 2011 as amended.

Furthermore, any potential further developments in this area may have an effect on the important water sources in this area.

The reason for the loss of water from some of the important quarry pit habitats is still uncertain. Some of this may be due to natural sediment accumulation. Further detailed hydrological investigation is required.

4.2.5 Recommendations

1. **Physical cutting and removal of scrubland vegetation will be required in some areas of wetland vegetation, particularly around the residential pond. Herbicides should not be used in the management of scrub as there is likelihood that these chemicals could enter the water sources and cause damage to wetland vegetation. An exception to this is the targeted weed wipe treatment at the bases of *Rhododendron ponticum* plants (after physical cutting and removal of the plant material), which occurs in this general area. *R. ponticum* also occurs in a former bog area (now wet grassland) at the northern end of Figure 9 and should be eradicated from this location also, using a similar methodology.**
2. **Consider the feasibility of digging down into the old dried out quarry pit where the former *Eleogiton fluitans* population was previously identified**, (see Figure 9 below) in order to expose the water table and attempt to re-invigorate this historic population. This requires further investigation of the substrate in the pit to see if this is feasible. If organic sediment build up has caused the drying out, removing this substrate would be feasible, however, if the pit is largely made up of open bedrock and water has simply diverted/ponded elsewhere (e.g. in the residential pond just to the south), then restoration works may not be feasible.

Figure 9 Greenhollows (Site 2) map.

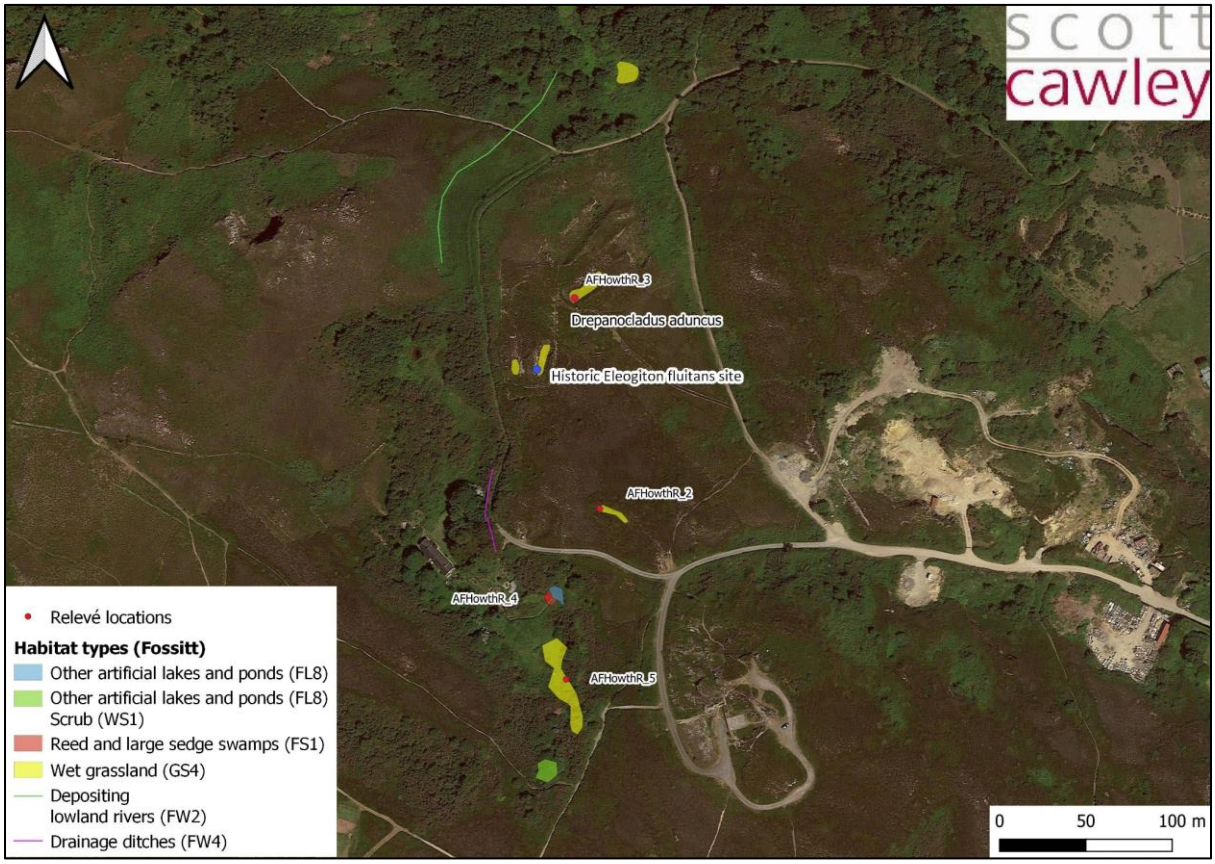


Plate 8 Relevé AFHowthR_2 in Site 2: Juncus effusus – Rumex acetosa grassland (GL2D).

Plate 9 Relevé AFHowthR_3 in Site 2: currently considered to be an unusual mosaic assemblage of GL1D-FE1A-GL2D – the rare aquatic moss Drepanocladus aduncus occurs in the open water of this old quarry pool (as in the left foreground of this image).

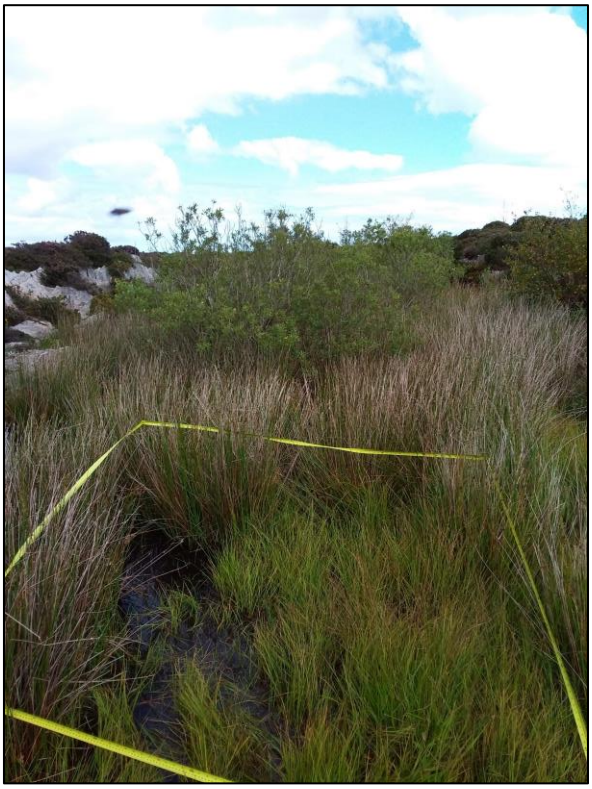


Plate 10 Relevé AFHowthR_4 in Site 2: reed beds of Phragmites australis – Equisetum fluviatile swamp (FW3E), directly adjacent to the residential pond.

Plate 11 Pond near the residence in Site 2

4.3 Site 3 – Bog of Frogs

4.3.1 Overview

This former area of bog, located in a topographical depression in the centre of Howth Head directly south of Deer Park Golf Club, was once more extensive and covered a larger area near Balkill Cottage, as indicated on the historic six inch colour maps from 1837-1842 and the historic 25 inch maps from 1888-1913, although the true extent of inundated ground in this area is not readily gleanable from the historical maps (on the other hand, ground to the immediate north may be inferred from maps as being marshy prior to reservoir construction). This site may have been one of the boggy seepage areas from which the original Bloody Stream course emanated (before the Howth Reservoir was constructed). The site has reduced significantly in size and wetness since the days of Hart (1887). Today, there is only a very small area of existing wetland habitat. Much of the original extent has been drained and is now covered with more or less dry woodland and scrubland. The only wetland habitat that occurs at the site today is wet grassland (GS4). No true bog/marsh vegetation can be found. This is indicative of major losses in this wetland in recent decades. This site is currently ranked as the sixth most important botanical wetland site on Howth Head due to its historic importance as a wetland site and the potential for future restoration measures to be implemented (see Table 2).

4.3.2 Hydrology

No discrete inflow into the site was observed. Therefore, diffuse runoff from elevated lands to the south is considered to be the primary inflow into the site. The outflow was difficult to confirm due to heavy overgrowth but is assumed to be an easterly continuation of the channel inside the northern perimeter. Bed elevation in the outflow channel at the eastern end of the bog was 101.58 mOD. Water is subsequently directed to a confluence 100 m further east where it meets water coming from the Greenhollows area. A separate drainage channel north of the bog serves the golf course and it is assumed there is no subsurface connectivity between this drain and the bog, though this requires further confirmation. These merged channels enter a 200 mm concrete culvert that transmits water to the nearby Howth Reservoir. This site itself previously contained permanent water as evidenced by ruins of a pumphouse on the western edge of the site. Closer inspection of the perimeter of the site is required during winter/wetter weather conditions or after scrub removal works at the site in order to ascertain the drainage outfall(s) from the site. The peat substrate here suggests a low permeability base.

4.3.3 Vegetation Description

The main wetland site is made up of wet grassland (GS4) vegetation, and specifically, the community *Juncus effusus – Rumex acetosa* grassland (GL2D). This community is characterised by the presence of abundant and well-grown *Juncus effusus* (Soft Rush), along with the frequent presence of such species as *Ranunculus repens* (Creeping Buttercup). Also occurring here in a mosaic with the GL2D is *Juncus acutiflorus – Holcus lanatus* grassland (GL1A). This is a similar wet grassland community to that of GL2D, however it differs due to the the dominant presence of *Juncus acutiflorus* (Sharp-flowered Rush), along with *Holcus lanatus* (Yorkshire Fog), *Anthoxanthum odoratum* (Sweet Vernal-grass) and *Agrostis stolonifera* (Creeping Bent). An unusual version of this community occurs at the site, in which large quantities of *Comarum palustre* (Marsh Cinquefoil) are present. Both communities are relatively species-poor and of low considered conservation value. This site is now relatively small and the vegetation is relatively species-poor, with no existing 'bog' or marsh vegetation present. The edges of the site are being increasingly dominanted by *Betula pubescens* (Downy Birch) scrub and stands of *Pteridium aquilinum* (Bracken).

4.3.4 Threats and pressures

This site was once one of the more important semi-natural wetland sites on Howth Head, and it has reduced in quality significantly in very recent years. No known true bog or marsh vegetation is present here. Local drainage pressure, particularly from a drainage channel at the eastern of the site, as well as scrub and

Pteridium aquilinum encroachment in the site are primary threats. The impact of drainage can be threefold with mechanisms including (i) interception of the natural inflows such that they bypass the site altogether, (ii) lowering of groundwater levels due to nearby open and subsurface drains such as those serving the adjacent golf course, and (iii) open drainage channels within the site which are lowering water levels in the wetland directly.

4.3.5 Recommendations

1. Consider installing standard water level logger to monitor water levels and qualitatively measure efficacy of any measures implemented.
2. Probing to confirm extents and depths of peat substrate.
3. **Remove scrub to clarify outfall channel route, invert levels, level control, etc. Also confirm minimum continuous level of perimeter berm and ensure no other outlet pipes.**
4. **Explore feasibility of installing a cofferdam/weir on the outlet channel to raise water levels in the bog. Need to ensure all perimeter berms are continuous to a level above weir top.**
5. **Topographical survey of bog and immediate area to confirm variation in wetted extents as a function of water levels. Calculate gain in wetted area from raising water levels.**
6. Explore feasibility of increasing current contributing catchment area to the bog by redirecting drains, e.g. woodland to the west, Greenhollows area.
7. **Combine re-wetting with intermittent physical cutting of encroaching *Pteridium aquilinum* and *Betula pubescens* (Downy Birch)/*Rubus fruticosus* agg. (Bramble) scrub (bracken cutting twice per year, at start and end of summer; scrub cutting in winter and all cuttings should be removed from the site). No herbicide should be used for this purpose. *B. pubescens* trees can be uprooted and removed physically by a digger.**
8. Trial introduction of goats in this area to reduce scrub. This measure has been employed nearby to manage scrub encroachment in Annex I heathland habitat. The measure may be challenging as the area of wetland itself is quite small and open and is surrounded by woodlands, and paths are heavily trafficked by walkers.

Figure 10 Bog of Frogs (Site 3) map.

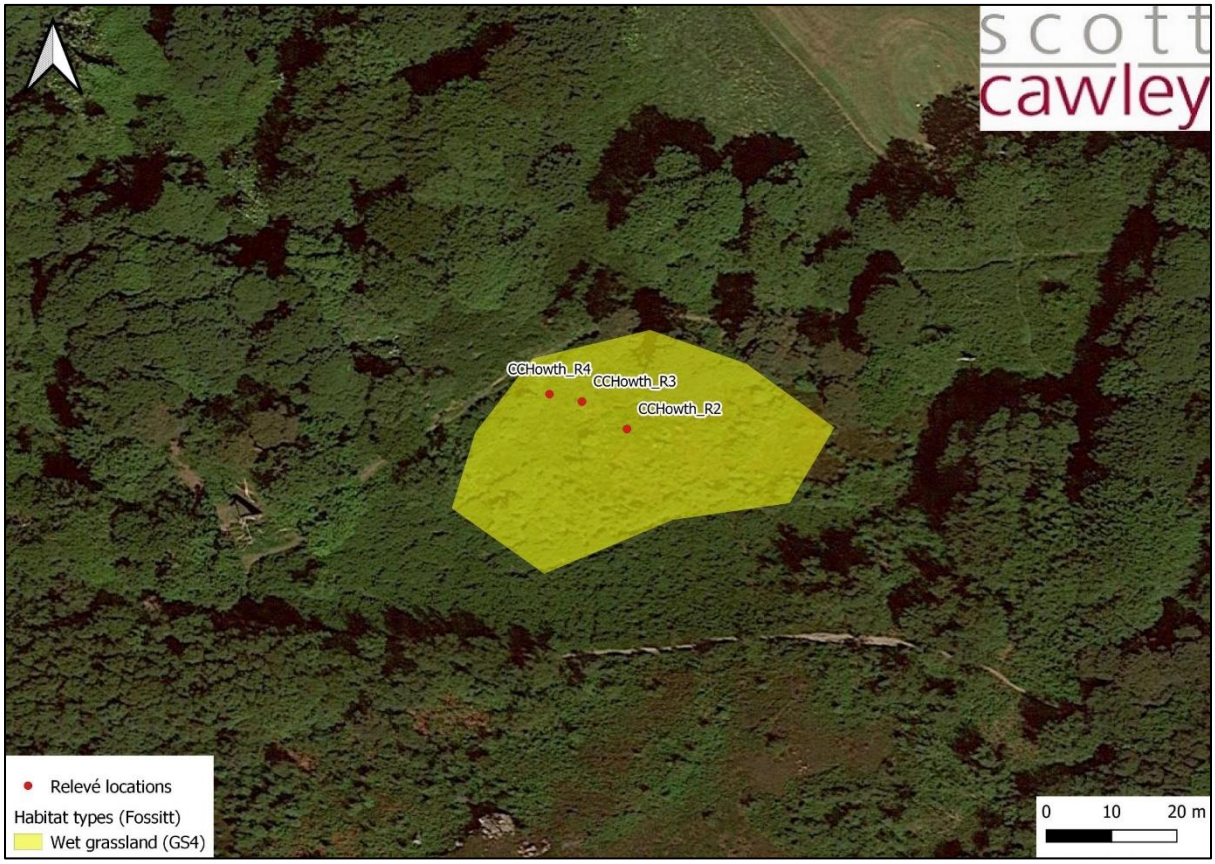


Plate 12 Juncus effusus – Rumex acetosa grassland (GL2D) in site 3. Betula pubescens (Downy Birch) can be seen invading the edge of the site in the background.

Plate 13 Juncus acutiflorus – Holcus lanatus grassland (GL1A) community, in this case, with large amounts of Comarum palustre (Marsh Cinquefoil), in site 3.

Plate 14 Ditch running through Juncus effusus – Rumex acetosa grassland (GL2D) in site 3: a likely source of the increased drainage that this site is experiencing in recent years.

4.4 Site 4 – Whitewater Brook

4.4.1 Overview

Whitewater Brook is an important local stream, located in the south-east of Howth Head, which flows in a south-easterly course and discharges directly into the Irish Sea at a rocky beach located directly north of the Baily Lighthouse. The stream still follows more or less the same course as presented in the historic maps. Notably, a sluice gate on the stream near the Carrickbrack Road is presented on the 25 inch historic maps from 1888-1913. This demonstrates that the stream flow in this area has been managed and altered since at least the late 1800s. The section of the stream located on the slope directly adjacent to the sea is its most natural/undisturbed section. Some interesting vegetation occurs along this stretch. Further upstream, the stream becomes heavily encroached by scrub and also is culverted for most its course. Some of the water from this stream has also been diverted into an ornamental pond (or rather three separate but interconnected ponds) located directly south of a large car park off Carrickbrack Road. Another pond has also been created at Hilltop House Pond, west of Carrickbrack Road, by diverting water from the stream. This site is currently ranked as the fifth most important botanical wetland site on Howth Head due to varied semi-natural lowland stream and pond vegetation that occurs along the lower course of the stream (see Table 2).

4.4.2 Hydrology

The water of this stream originates from surface runoff from exposed Cambrian bedrock on the upper catchment on the south-eastern slopes of Ben Linn, and includes road runoff and a tributary along Tweedy's Lane from the Summit tanks. From there, the stream flows as a small dendritic network and drains the minor valleys on elevated ground which converge to a single inflow at Hilltop House Pond. The stream then flows in an eastern/south-eastern direction through a grassland field grazed by horses towards Thormanby Road from where it proceeds in a south-easterly course, with ponding occurring intermittently. The stream discharges directly into the Irish Sea at a rocky beach located directly north of the Baily Lighthouse and Dungriffin Promontory.

4.4.3 Vegetation Description

This depositing/lowland river (stream) (FW2) habitat contains at least two different vegetation communities of note. The most common community within the stream is the *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E). This community is characterised by the abundant and constant presence of both *Helosciadium nodiflorum* (Fool's-water-cress) and *Nasturtium officinale* agg. (Water-cress), often alongside some grass species such as *Agrostis stolonifera* (Creeping Bent) and *Phalaris arundinacea* (Reed Canary-grass). The presence of these constant species indicates that the water is likely quite base-rich and nutrient-enriched.

At relevé AFHowthR_7, a different wetland community can be seen growing over the stream, with dominant stands of *Equisetum telmeteia* (Great Horsetail), also with *Epilobium hirsutum* (Great Willowherb) and *Holcus lanatus* (Yorkshire Fog). Although this is a rather unusual assemblage of species, this community has some affinities to *Holcus lanatus – Lolium perenne* grassland (GL2C), which is a species-poor and often wet pasture (although not in this case) community. This area is also becoming heavily encroached with scrub, including *Rubus fruticosus* agg. (Brambles) and *Pteridium aquilinum* (Bracken).

Reed and large sedge swamp (FS1) vegetation occurs at the artificial pond (FL8) located directly south of the large car park by Carrickbrack Road. Here, *Eleocharis palustris – Agrostis stolonifera* marsh/fen (FE3C) was recorded at relevé AFHowthR_8. This is a marshy community of base-rich, mildly eutrophic water conditions, with such constant species such as *Eleocharis palustris* (Common Spike-rush), *Agrostis stolonifera*, *Mentha aquatica* (Water Mint), *Helosciadium nodiflorum* and *Nasturtium officinale* agg. The main threats to this community include groundwater pollution, drainage, over- and/or under-grazing and reclamation (NBDC, 2020). This pond contained a few introduced species, most notably *Nymphoides peltata* (Fringed Water-lily), which has become invasive in this pond and is listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011. *Typha latifolia* (Bulrush) is also

adundant in the pond. This is most comparable to the *Phragmites australis – Typha latifolia* swamp (FW3B) community, although this *Typha*-dominated form (with no *Phragmites australis* (Reed) present) needs to be updated as a new swamp community (P. Perrin, pers. comm., November 2020).

Another pond occurs surrounded by dry woodland located directly west of Carrickbrack Road at Hilltop House, and is referred to as the Hilltop House Pond. This pond is also linked to the course of the Whitewater Brook. It has more or less no wetland vegetation within it or on its banks; however a few *Salix cinerea* subsp. *oleifolia* (Rusty Willow) trees are located near it and perhaps indicate a certain degree of occasional flooding of the pond (however, the willows were very few in number and were not extensive enough to classify the woodland as wet woodland). A few non-native species have been introduced in the pond and are now becoming invasive here, including *Lysichiton americanus* (American Skunk-cabbage), *Gunnera tinctoria* (Giant-rhubarb) and *Rhododendron ponticum* (Rhododendron). All of these species are also listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011.

The vegetation near the discharge point of the Whitewater Brook into the Irish Sea is of particular interest as this area of the stream is the most natural/unmodified section and there is less scrub encroachment on this coastal slope. Although the slope was too steep to complete a relevé safely, a species list was taken for this section of the stream. The most prominent species along this portion of the stream are *Eupatorium cannabinum* (Hemp-agrimony), *Agrostis stolonifera, Schedonorus arundinaceus* (Tall Fescue), *Epilobium hirsutum,* and within the stream itself, *Helosciadium nodiflorum, Fontinalis antipyretica, Pellia endiviifolia* and *Cratoneuron filicinum*. The vegetation within the stream here conforms with the *Fontinalis antipyretica – Myriophyllum alterniflorum* aquatic community (FW2A). This species-poor, bryophyte-dominated community has only the aquatic moss *Fontinalis antipyretica* as a constant, whilst other species may occur include *Helosciadium nodiflorum*. This community may be negatively affected by "*eutrophication, siltation and river engineering including dredging and canalisation*" (NDBC, 2020). Similar vegetation occurs in a shorter water channel by the coast located to the south of the Whitewater Brook.

4.4.4 Threats and pressures

Scrub encroachment and spread of invasive species in these habitats are primary threats. For example, the Third Schedule invasive species *Nymphoides peltata* occurs in one pond located south of the car park by Carrickbrack Road, whilst at Hilltop House Pond, the Third Schedule *Lysichiton americanus* (American Skunk-cabbage), *Gunnera tinctoria* (Giant-rhubarb) and *Rhododendron ponticum* (Rhododendron) also occur. Historic culverting and diversion of water courses for developments has also put pressure on this stream. Eutrophication caused by upstream water inputs from housing and other developments may also threaten these wetlands. Garden waste has been dumped in the stream on the eastern side of Thormanby Road and this is having a negative impact on water quality and possibly increasing upstream flooding. Between Windgate Road and Carrickbrack Road there is significant poaching of the stream bed and bank erosion caused by grazing horses. Potential direct defecation from grazing horses may also be an issue.

4.4.5 Recommendations

1. **Sample water quality of Hilltop House Pond as it is one of the few wetland features within this site with no upgradient pressures.**
2. Consider installation of a flowmeter/level logger to determine wetted extents of Hilltop House Pond. This could be a potential site for the local authority to take in charge.
3. **Restrict livestock access into the stream at the section where it flows through a field between Windgate Road and Carrickbrack Road.**
4. Check animal access in fields in vicinity of Cabena's Well (see Appendix III for location). Provision of a metered animal drinker if stream is only potable water source for animals.
5. Install gully or similar to capture stormwater between car park and pond adjacent to north-eastern corner of large car park on Carrickbrack Road.

6. **Removal of garden waste dumped in stream on the eastern side of Thormanby Road. Introduce measures to prevent further dumping of garden waste in this area, including signage and fencing along the eastern side of the roadway (where currently only a low bank occurs).**
7. **Intermittent physical cutting of scrub (in winter and all cuttings should be removed from the site), especially in the area east of Thormanby Road, which is extremely dense.**
8. **Monitoring for the presence of invasive species should be conducted on an ongoing basis across the entire site and if necessary, they should be physically removed, including the invasive *Nymphoides peltata* population in the pond located south of large car park by Carrickbrack Road and the invasive *Lysichiton americanus* (American Skunk-cabbage), *Gunnera tinctoria* (Giant-rhubarb) and *Rhododendron ponticum* (Rhododendron) populations at Hilltop House Pond. However, herbicides should not generally be used for this process as this will enter the water sources and cause damage to local wetland vegetation. Therefore, physical removal is the only safe removal option for these species.**
9. Include inlet, weir overflows and downstream culvert in regular inspection programme.
10. **Conduct a catchment survey and water quality testing to determine source of nutrient enrichment in pond south of the large car park by Carrickbrack Road**.

Figure 11 Whitewater Brook (Site 4) map.

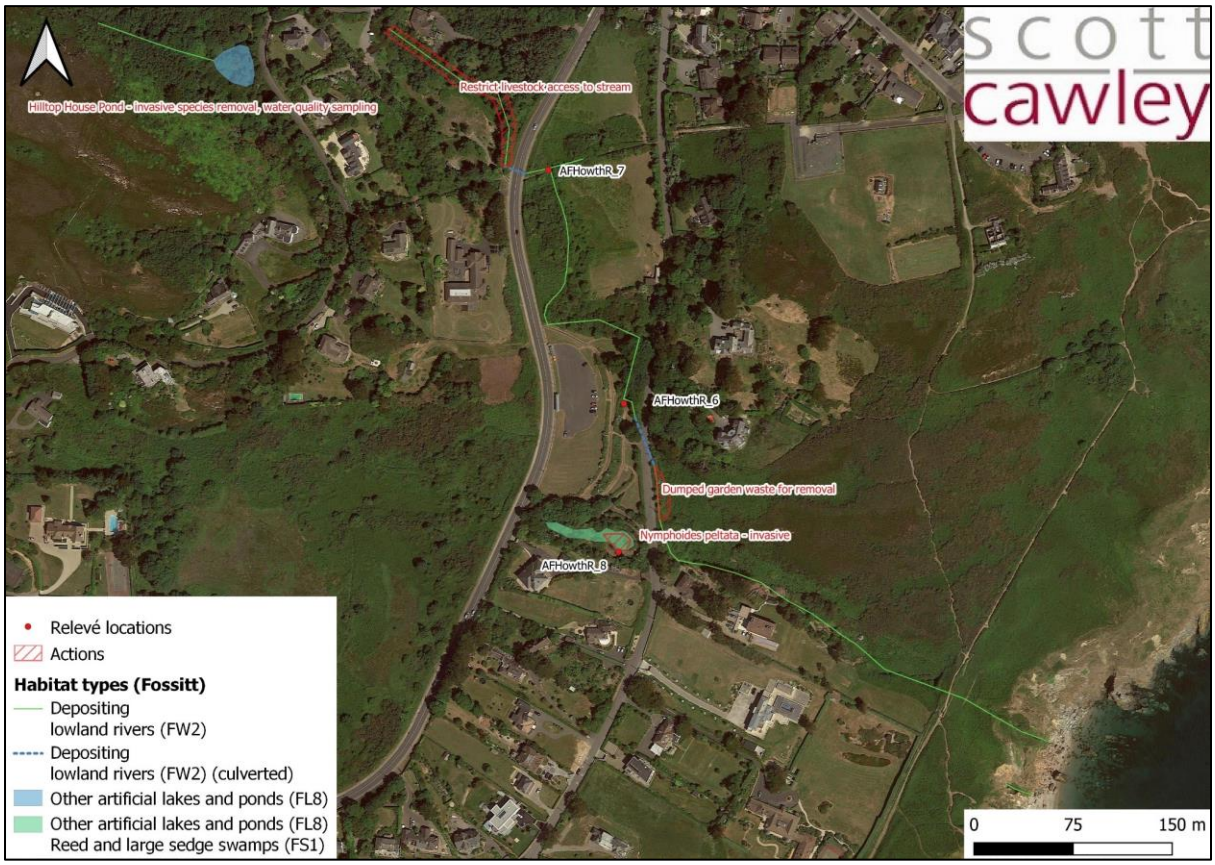


Plate 15 Whitewater Brook as it discharges into the Irish Sea (black arrow indicates location of stream).

Plate 16 Whitewater Brook as it discharges into the Irish Sea – dense wetland vegetation present, including large stands of Eupatorium cannabinum (Hemp-agrimony).

Plate 17 Relevé AFHowthR_6 in Site 2: Apium nodiflorum – Rorippa nasturtium-aquaticum agg. aquatic community (FW2E).

Plate 18 Relevé AFHowthR_8 in Site 2: Eleocharis palustris – Agrostis stolonifera marsh/fen (FE3C), with the invasive aquatic species Nymphoides peltata (Fringed Water-lily).

Plate 19 Hilltop House Pond, with the invasive species Lysichiton americanus (American Skunk-cabbage).

4.5 Site 5 – Kilrock Quarries

4.5.1 Overview

Kilrock Quarries is an area of former quarried ground, which was quarried since at least the 1800s, although no significant changes in quarried area have been seen since the publication of the 25 inch maps from 1888-1913, which suggests that quarrying ceased by the early 1900s. It is now disused and has been recolonised by semi-natural vegetation. It is located in the north-east of Howth Head near to the Howth Cliff Walk pathway.

Three main quarry voids occur in this area, namely the south-western, eastern and northern voids (Envirologic, 2020). The northern void located directly south of the Howth Cliff Walk car park in particular contains (unlike the other two voids) very significant local wetland habitat and is one of the most important sites for wild plants on Howth Head. This site is currently ranked as the most important botanical wetland site on Howth Head due to the presence of rare Dublin plant species, as well as an EU Habitats Directive Annex I habitat (see Table 2). Water emerges from the slopes of this disused quarry and flows down through the vegetation at its base and down along the approaching path, creating the ideal conditions for an unusual fen-like wetland to form. Some localised ponding and water channel flow also occur in the other voids in the site, however, these have not produced any wetland habitat of note to date.

4.5.2 Hydrology

The water in the northern void of interest largely originates from precipitation on the slopes of the quarry and flows down through the base of the quarry and over the approaching path. The type of plants species which occur at the site (including *Chara vulgaris*) indicate that the water is probably base-enriched in nature, and indeed limestone gravels were noted by Envirologic (2020) in the west of the northern void during the hydrology survey of the site. No significant seeps were observed on the 10m high exposed faces within the northern void, with bedrock at this location massive in structure. Small topographically enclosed depressions are saturated (presumed to be rainwater) and may display some ponding. Some minor seepages were also observed closer to the western end of the northern void. Some localised ponding also occurs in the other voids in the site, and a surface water channel also flows from east to west between the northern and south-western voids. This stream restricts potential for infiltration and subsequent re-emergence of groundwater in the northern void.

4.5.3 Vegetation Description

The main quarry wetland site comprises both wet grassland (GS4) and rich fen and flush (PF1) vegetation. Wet grassland (GS4) is abundant here, and specifically, the community *Agrostis stolonifera – Filipendula ulmaria* marsh-grassland (GL1B). This species-rich community is characterised by the presence of abundant *Agrostis stolonifera* (Creeping Bent), along with the frequent presence of such species as *Festuca rubra* agg. (Red Fescue), *Holcus lanatus* (Yorkshire Fog) and sedges including *Carex nigra* (Common Sedge) and *Carex flacca* (Glaucous Sedge). Some examples of this community can be considered to have affinities with the EU Habitats Directive Annex I habitat 6410 *Molinia* meadows, however not in this case, as there are insufficient positive indicator species (and no high quality indicator species) for that habitat type. The primary threats to this community are grassland improvement, abandonment and changes to the flooding regime (NBDC, 2020).

The similarly abundant fen/flush vegetation at this site was an unusual and very species-rich assemblage of species. There was no statistically significant relationship between this assemblage of species and any wetland community, according to the ERICA statistical analysis output; however, it has closest affinity was to *Carex nigra – Ranunculus flammula* fen (FE3A). The notable species *Equisetum variegatum* (Variegated Horsetail) and *Samolus valerandi* (Brookweed) occur in the open fenny vegetation at this site that has formed over the path leading up the quarry itself (see Figure 12). The fen vegetation conforms to the EU Habitats Directive Annex I habitat [7230] Alkaline fens. Positive indicator ("*typical*") species for this habitat as per NPWS (2019) which occur at the site include *Equisetum palustre* (Marsh Horsetail)*, Succisa pratensis* (Devil's-bit Scabious)*, Linum catharticum* (Fairy Flax)*, Ranunculus flammula* (Lesser Spearwort)*, Galium*

palustre (Marsh Stitchwort), *Chara* spp. (specifically *Chara vulgaris* occurs here), *Briza media* (Quaking-grass), *Molinia caerulea* (Purple Moor-grass), *Carex flacca* (Glaucous Sedge), *Carex nigra* (Common Sedge), *Carex panicea* (Carnation Sedge), *Mentha aquatica* (Water Mint), *Juncus articulatus* (Jointed Rush) and *Calliergonella cuspidata* (with at least 14 species in total present). Denyer & Hodd (2019) also discovered the rare Dublin fen moss *Campyliadelphus elodes* at this fen within the quarry; the first record for this species from Howth Head and the first record of this species for Co. Dublin since 1852. Finally, the rare aquatic moss *Drepanocladus aduncus* was discovered in this quarry by David Holyoak in 2007; the first known record of this species on Howth Head (Melinda Lyons, pers. comm., September 2020).

4.5.4 Threats and pressures

Scrub encroachment and future spread of invasive species (which was noted as a threat arising from illegal garden waste dumping in this area by Doogue (2009)) in this site are primary threats. Furthermore, any increases in human footfall (due to the busy nearby car park and walking pathways) in these quarry pits may also threaten the site.

4.5.5 Recommendations

1. **Physical cutting and removal of scrubland (including dense areas of *Rubus fruticosus* agg. and *Ulex europaeus*) vegetation (in winter and all cuttings should be removed from the site) in some areas may be required intermittently, as such habitats can become degraded by scrub in the absence of management/grazing. This particularly applies to the less botanically interesting eastern and south-western voids, which could nonetheless develop wetland vegetation if managed appropriately.**
2. **Monitoring for the presence of invasive species should be conducted on an ongoing basis, and if necessary, any invasive species (*e.g. Buddleia davidii* found to be present should be physically removed. Herbicides should not be used in the management of scrub as there is likelihood that these chemicals could enter the water system and cause damage to local wetland vegetation.**
3. Furthermore, no new access pathways should be built in and/or around this site as this would lead to increased levels of habitat loss and erosion, due to from increased human footfall.

Figure 12 Kilrock Quarries (Site 5) map.

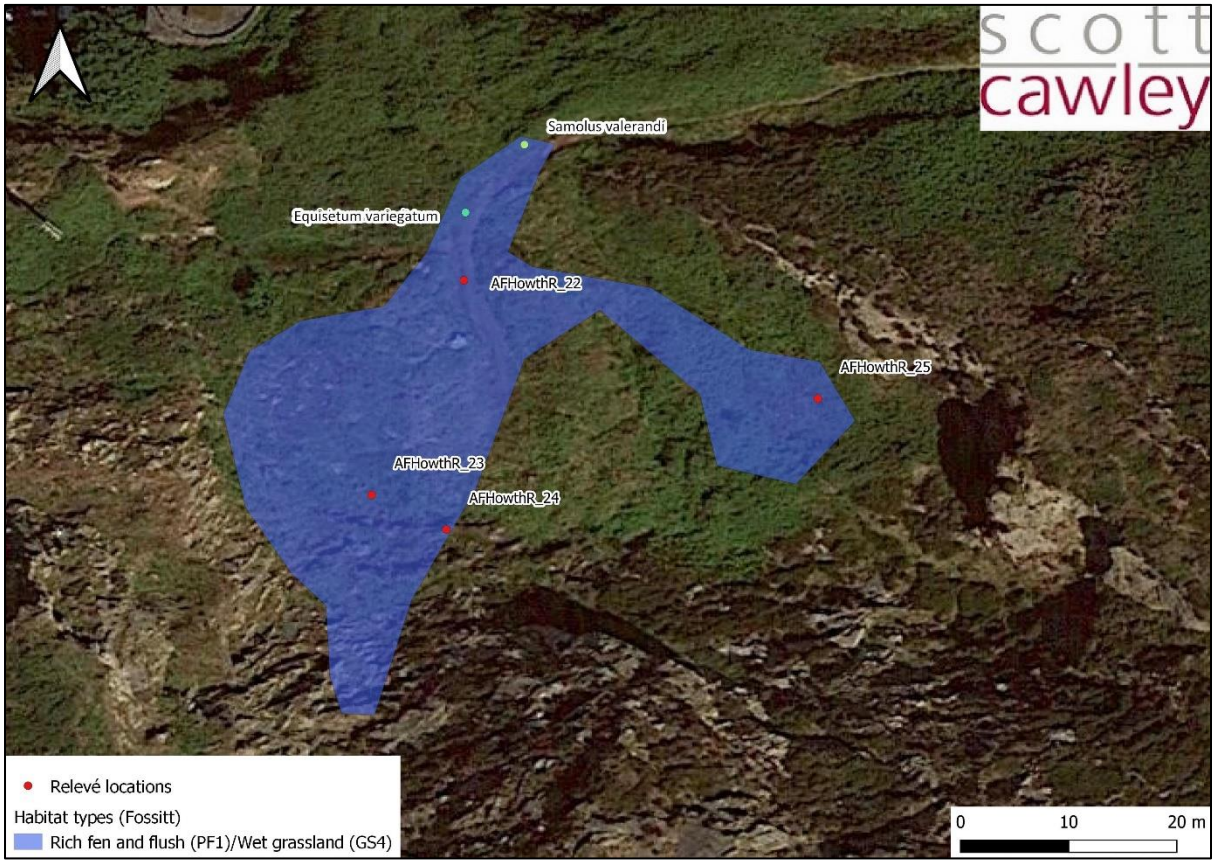


Plate 20 Relevé AFHowthR_22 in Site 5: most comparable to Carex nigra – Ranunculus flammula fen (FE3A).

Plate 21 Relevé AFHowthR_23 in Site 5: Agrostis stolonifera – Filipendula ulmaria marsh-grassland (GL1B).

4.6 Site 6 – Coulcoor Brook

4.6.1 Overview

Coulcoor Brook (otherwise known as Kilrock Stream) is a short and partly culverted stream which flows northwards directly west of Kilrock Road towards and under the Balscadden Road, after which it discharges into Balscadden Bay in the north-east of Howth Head. The stream still follows more or less the same course as in the historic maps, *i.e.* 25 inch maps from 1888-1913. However, today, as the stream is increasingly silted and culverted in sections, there is limited wetland vegetation to be found here, although some does still occur on open grassy ground located directly south of Balscadden Road. This site is currently ranked as the eleventh most important botanical wetland site on Howth Head due to the fact that the stream shows limited wetland vegetation, but has the potential for enhancement/restoration measures(see Table 2).

4.6.2 Hydrology

The Coulcoor Brook is fed by diffuse runoff from an exposed hilltop in Upper Cliff Road area, the stormwater network serving the roads and hardstanding may also outfall to the stream (unconfirmed). The upper catchment boundary is not easy to delineate. Runoff passes through the Upper Cliff Road area of houses before entering an open channel at the top of Cowbooter Lane. Close to where it passes the allotments the stream is culverted from the eastern to western side of Cowbooter Lane from where the culvert continues behind a stone wall as far as Nashville Road. Between Nashville Road and Balscadden Road the stream flows through rear gardens of private residences. The stream is culverted beneath Balscadden Road prior to coastal outfall through a narrow gorge in a steep cliff at Balscadden Bay.

4.6.3 Vegetation Description

The only notable wetland vegetation associated with the Coulcoor Brook occurs directly south of Balscadden Road, near where the culverted stream flows under the road and discharges into Balscadden Bay. Here wet grassland (GS4) vegetation has formed. Two main wet grassland communities occur at this location. The first of which is *Holcus lanatus – Lolium perenne* grassland (GL2C), which is a relatively species-poor community of low conservation value. It is often dominated by *Holcus lanatus* (Yorkshire Fog)*, Agrostis stolonifera* (Creeping Bent) (and *Lolium perenne* (Perennial Ryegrass) in the more improved examples, this species was not found here), along with *Ranunculus repens* (Creeping Buttercup) (NBDC, 2020). The example at this site was unusual in that considerable amounts of *Eupatorium cannabinum* (Hemp-agrimony) occurred, along with some invading *Urtica dioica* (Common Nettle) and *Cirsium arvense* (Creeping Thistle), indicative of the vegetation drying out here.

The second wet grassland community recorded at this site was *Agrostis stolonifera – Ranunculus repens* marsh-grassland (GL2A), which as the name suggests is dominated by *Agrostis stolonifera*, along with with *Ranunculus repens, Galium palustre* (Marsh Stitchwort)*, Potentilla anserina* (Silverweed)*, Calliergonella cuspidata* and other species. It is a relatively species-poor community which is generally managed through rough grazing; however not at this site. The main threats to this community are grassland improvement, abandonment and changes to flooding regime (NBDC, 2020).

4.6.4 Threats and pressures

The grassland site here is primarily threatened by scrub (including dense *Rubus fruticosus* agg.) encroachment (due to abandonment and drying out of the grassland), further reductions in water/flooding influence and potential spread of invasive species (although none were recorded here during the present surveys). The heavy silting of the stream has limited the contact of the water with the surface vegetation, which is leading to the vegetation becoming increasingly dried out. Eutrophication caused by upstream water inputs from housing developments may also threaten this wetland.

4.6.5 Recommendations

1. **Consider the feasibility of digging down into sections of the stream to better access the water table and remove siltation, particularly near the wet grassland area located directly south of Balscadden Road, to increase the wetness of the surface vegetation.**
2. Consider clearing scrub (*e.g.* dense *Rubus fruticosus* agg.) from sections of the stream (in winter and all cuttings should be removed from the site) if this becomes a serious issue in the future.
3. **Conduct a full water quality survey to assess potential eutrophication effects within the water course.**

Figure 13 Coulcoor Brook (Site 6) map.

Plate 22 Relevé AFHowthR_19 in Site 6: Holcus lanatus – Lolium perenne grassland (GL2C), with large stands of Eupatorium cannabinum (Hemp-agrimony).

Plate 23 Relevé AFHowthR_20 in Site 6: Agrostis stolonifera – Ranunculus repens marsh-grassland (GL2A), with large stands of Epilobium hirsutum (Great Willowherb).

4.7 Site 7 – Bogeen Stream

4.7.1 Overview

The Bogeen Stream (otherwise known as the Gray's Brook or Balscadden Stream) originates from seepage on slopes surrounding Gray's Wood (site 1) on Thormanby Hill in the east of Howth Head. This can be seen in Hart's (1887) map of the area, which shows the "*Boggeen*" Stream rising on the slope located directly south-east of Gray's Wood. Today this stream has been channelised into a large ditch in the middle of this woodland, and provides important wetland habitat for this woodland which is currently drying out due to development-related drainage. From here it flows in a northward direction until it reaches the transition of Balglass Road to Main Street, where it becomes fully culverted and eventually discharges into the Irish Sea at Howth Harbour, with no surface water or vegetation existing north of this road. This site is currently ranked as the ninth most important botanical wetland site on Howth Head due to its hydrological connection with the important Gray's Wood wet woodland (site 1) and its lowland stream vegetation (see Table 2).

4.7.2 Hydrology

The Bogeen Stream originates from seepages on slopes surrounding Gray's Wood on Thormanby Hill, and has been channelised into a large ditch in the middle of this woodland. From here it flows in a northward direction, mostly through built up areas, culverted in small sections as it flow under roadways and private houses. These culverts are composed of a variety of structure types and orifice sizes, generally set within cast/block headwalls. Upgradient of Dungriffin Road the stream flows along a constructed stone channel within private gardens, which includes a number of small weirs and pools. Downstream of Dungriffin Road the channel steepens significantly and the profile changes accordingly (the bank vegetation changes to predominantly scrub). Bed substrate becomes coarser, composed of angular cobbles and boulders. The channel enters a short culvert crossing Dungriffin Villas adjacent to the Irish Water compound. At the transition of Balglass Road to Main Street the stream enters a culvert (there is no surface water or vegetation existing north of this culvert.) which carries flow along Main Street to the outfall point at Howth Harbour located directly east of Howth Yacht Club. This culvert inlet was not observed due to dense scrub cover.

4.7.3 Vegetation Description

This depositing/lowland river (FW2) habitat contains one dominant vegetation community, namely, the *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E). This community is characterised by the abundant and constant presence of both *Helosciadium nodiflorum* (Fool's-water-cress) and *Nasturtium officinale* agg. (Water-cress), often alongside grass species such as *Agrostis stolonifera* (Creeping Bent) and *Phalaris arundinacea* (Reed Canary-grass). The presence of these constant species indicates that the water is likely quite base-rich and nutrient-enriched. This vegetation occurred in both relevés AFHowthR_1 and AFHowthR_18 that were recorded within the stream itself, and was found to be dominant in most/all other areas of the stream course, including in the southern section within Gray's Wood. This community can be negatively affected by eutrophication, dredging, canalisation and livestock trampling. Examples of this community with "*a relative abundance of crowfoots (Ranunculus spp. subgenus Batrachion) correspond with the EU HD Annex I habitat 3260 Floating river vegetation*" (NBDC, 2020), however, no significant Batrachian *Ranunculus* populations were found to occur within the stream, another indicator of reducing stream quality in the site.

4.7.4 Threats and pressures

This stream habitat is under threat due to eutrophication, dredging, canalisation and upstream water source diversion due to housing and other developments. This is particularly the case with regard to the Thormanby Hill development site which occurs near the source of the stream itself.

4.7.5 Recommendations

1. **Consider intermittent removal of scrub (in winter and all cuttings should be removed from the site) in the portion of the stream just south of Balglass Road/Main Street to improve species-richness of stream bank vegetation in this area.**
2. Consider cleaning all culvert inlets and outlets of vegetation and include same in regular inspection programme to help improve water quality.
3. **Conduct a full water quality survey to assess potential eutrophication effects within the water course.**
4. Avoid any further culverting, building over the stream and/or further diversion of upstream water sources.

Figure 14 Bogeen Stream (Site 7) map.

Plate 24 Relevé AFHowthR_18 in Site 7: Apium nodiflorum – Rorippa nasturtium-aquaticum agg. aquatic community (FW2E).

Plate 25 Bogeen Stream in Gray's Wood (site 1).

4.8 Site 8 – Offington Wetland

4.8.1 Overview

Offington Wetland comprises a connected double pond area located at the western edge of Deer Park golf course, directly east of Offington Park in the north-west of Howth Head. Although this site is beginning to fill in, dry out and become invaded by invasive species, it is nonetheless a species-rich wetland site of high conservation importance. This site is currently ranked as the second most important botanical wetland site on Howth Head due to the presence of a rare Dublin plant species and, associated with this, an EU Habitats Directive Annex I wetland habitat, within the site (see Table 2).

4.8.2 Hydrology

There is a convergence of drainage channels at this wetland location from the golf course (which probably converge with Offington Stream further downstream), although flow directions and connectivity of same are unclear. The ponds were installed between 20 to 30 years ago to restrict people freely entering the golf course from Offington Lawn residential area. Due to health and safety concerns, the pond inlet and outlet levels were adjusted to ensure submerged depth was never greater than 300 mm. The ponds are unlined so there is some uncertainty around their ability to retain water across the entire base. The two ponds are separated by a small shelf. The drainage inflow is from Deer Park golf course, which may have been reduced with alterations to golf course drainage over the years, and drainage outflow is to Offington Park to the west. The hydrological surveys suggest that the ponds may not be hydrologically connected and that the lowered eastern end of the embankment facilitates a separate inflow. Hence it seems more plausible that each pond has its own independent inflow and outflow. This wetland reportedly holds standing water at certain times of the year (presumably during winter and after heavy rainfall).

4.8.3 Vegetation Description

This wetland site contains both wet grassland (GS4) and reed and large sedge swamps (FS1) vegetation. Wet grassland (GS4) is the most common habitat here, specifically the community *Holcus lanatus – Lolium perenne* grassland (GL2C). This is a relatively species-poor community considered to be of low conservation value often dominated by *Holcus lanatus* (Yorkshire Fog)*, Agrostis stolonifera* (Creeping Bent) (and *Lolium perenne* (Perennial Ryegrass) in the more improved examples, not found here though), along with *Ranunculus repens* (Creeping Buttercup) (NBDC, 2020). The example at this site was unusual in that included considerable amounts of *Epilobium hirsutum* (Great Willowherb), as well as a number of invasive non-native species, such as *Cordyline australis* (Cabbage-palm), *Acer pseudoplatanus* (Sycamore), *Cortaderia selloana* (Pampas-grass) and *Cyperus eragrostis* (Pale Galingale). However, none of these species are currently listed as Third Schedule (European Communities (Birds and Natural Habitats) Regulations 2011). The non-invasive *Malus domestica* (Apple) was also found growing in the northern pond area. Small quantities of reed and large sedge swamps (FS1) also occur, with *Typha latifolia* (Bulrush) being the dominant large sedge in this habitat. This is most comparable to the *Phragmites australis – Typha latifolia* swamp (FW3B) community, although this *Typha*-dominated form (with no *Phragmites australis* (Reed) present) needs to be updated as a new swamp community (P. Perrin, pers. comm., November 2020).

Another community within the site was *Carex nigra – Ranunculus flammula* fen (FE3A) (relevé CCHowth_R5). This highly variable and often species-rich habitat is characterised by the presence of large amounts of low-growing sedges, particularly *Carex nigra* (Common Sedge) and *Carex panicea* (Carnation Sedge), along with such species as *Ranunculus flammula* (Lesser Spearwort), *Hydrocotyle vulgaris* (Marsh Pennywort), *Mentha aquatica* (Water Mint), *Agrostis stolonifera* and *Juncus articulatus* (Articulated Rush). This community was most concentrated in the southern pond area. It is within this vegetation that the rare Dublin orchid *Epipactis palustris* (Marsh Helleborine) was recorded. This species is a high-quality indicator species for the Annex I habitat [7230] Alkaline fens, and the positive indicator species *Ranunculus flammula* and *Juncus articulatus* also occur at the site; therefore this area of habitat conforms to this EU protected habitat (NPWS, 2019).

4.8.4 Threats and pressures

The spread of invasive species in this site is of particular concern, along with a slow drying out of the site due to organic sediment accumulation. This will increasingly become accompanied by scrub encroachment, as well as further scrub and the spread of invasive species, if restoration actions are not taken. Eutrophication and other disruptions to water quality caused by upstream water inputs from the golf course and any future developments may also threaten this wetland.

4.8.5 Recommendations

1. Consider dredging the northern pond (starting with a trial in a portion of the pond followed by investigation of results), as it is slowly drying out due to organic sediment accumulation and becoming invaded by non-native species and scrub. No dredging should take place in the southern pond for the foreseeable future, as this has an important rare plant species population (*i.e. Epipactis palustris*).
2. Physical removal of invasive species from the entire wetland, particularly in the northern end where they are abundant (*i.e. Acer pseudoplatanus, Cordyline australis, Cortaderia selloana*, etc.), should be carried out. However, herbicide use should be avoided as there is likelihood that these chemicals could enter the water system and cause damage to local wetland vegetation.
3. Inflow and outflow locations require further clarification, in order to better understand the hydrology of the site.
4. Remove vegetation around inlets and outlets (see Appendix III for their locations). Reveal and clean outlet structure(s) of any blockages. Confirm any other drainage inflows.
5. Contributing catchments require further clarification. Confirm catchments to inflows via more detailed walkover survey of Deer Park drainage network.
6. Sample inflow water quality to assign baseline conditions. Include parameters to assess use of fertiliser, pesticide and herbicide. Discuss recommended protocol for use of same with groundsman. Consider this approach also with groundsmen at Sutton Golf Club and Howth Golf Club. All groundsmen encountered were open to liaising with local authority for assistance to develop/support enhanced biodiversity areas on their courses.
7. Ideal target water depth of northern pond to be determined by an Ecologist. Grade pond base and adjust inlet and outlet inverts accordingly, if possible/required – important to remain engaged with golf course staff on these proposals.
8. Investigate consequence of outlet becoming blocked. It may require a relief overflow to stormwater network. Include inspection of inlet and outlet as part of any future inspection programme.
9. Provide statutory protective measures as catchment/drainage infrastructure/pond layout may be manipulated as part of future development works which would disrupt regime.
10. Consider flow and level monitoring for minimum one year to assist understanding of winter/summer flow regimes and minimum and maximum water depths.

Figure 15 Offington Wetland (Site 8) map.

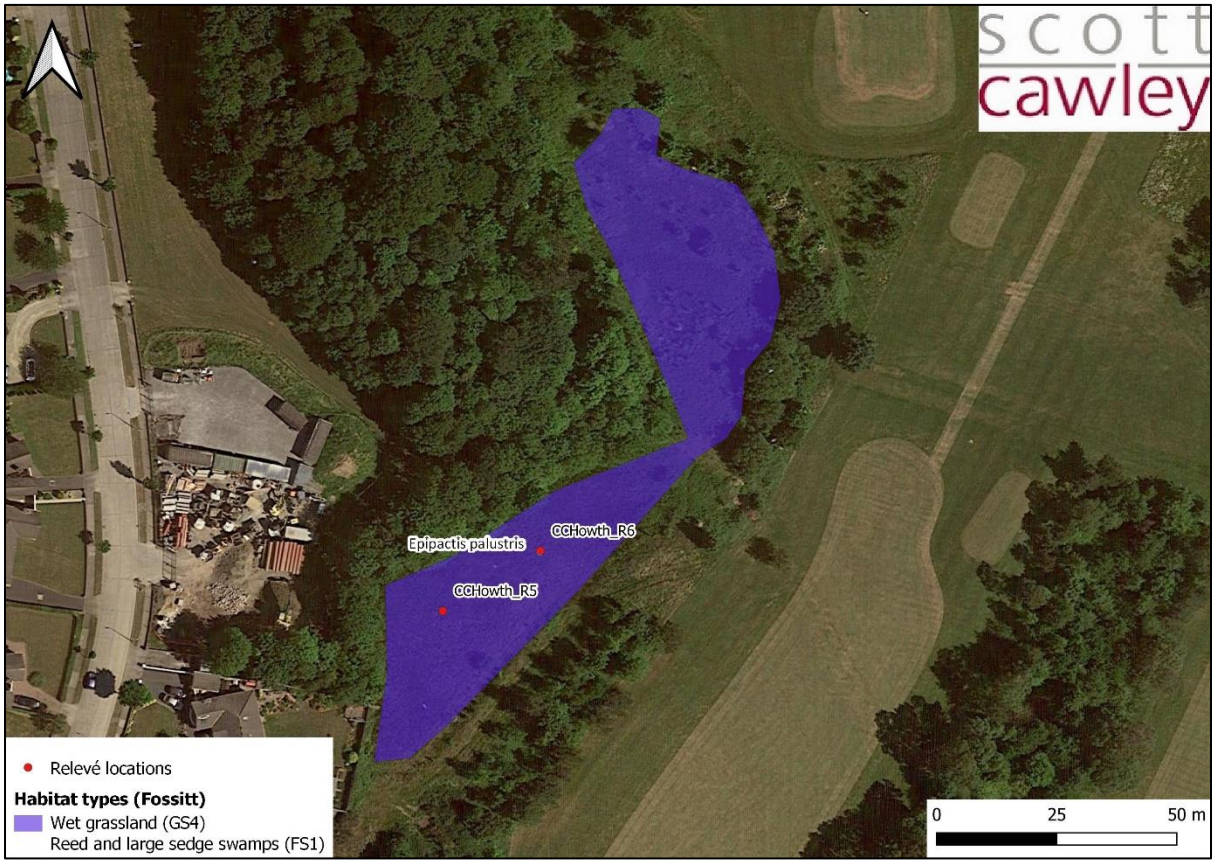


Plate 26 Reed and large sedge swamp (FS1) habitat with Typha latifolia (Bulrush) on northern side of Offington Wetland (Site 8) site, with the invasive Cordyline australis (Cabbage-palm) in the background.

Plate 27 Wet grassland (GS4) habitat on north side of Offington Wetland (Site 8) site, with the invasive Acer pseudoplatanus (Sycamore) and Cortaderia selloana (Pampas-grass) in the background.

4.9 Site 9 – Balsaggart Stream

4.9.1 Overview

The Balsaggart stream originates from runoff generated on raised ground in the eastern side of Howth Golf Course in the south of Howth Head and flows southwards to Dublin Bay on the southern coast of the peninsula Near the headwaters of the stream in Howth Golf Course, a pond occurs in a natural hollow, which is very likely to have been once the site of a natural lough and wetland site ("*site of lough*", as can be seen on the historic six inch colour maps from 1837-1842). The overall course of this stream is more or less the same as in this 1800s map, with the addition of an extra drainage ditch by the edge of a field south of Carrickbrack Road, which joins the stream course and has developed stream vegetation within it. The stream is open for much of its length, and has a multitude of different wetland habitats and vegetation communities associated with it. This site is currently ranked as the eighth most important botanical wetland site on Howth Head due to its wide variety of wetland stream vegetation (see Table 2).

4.9.2 Hydrology

The headwaters of the stream are formed in the eastern side of Howth Golf Course where runoff generated on raised ground to the east converges to a single rocky channel at the south-eastern corner of the course, discharging via a short 300 mm concrete piped culvert.

Near the headwaters of the stream in Howth Golf Course, a pond occurs in a natural hollow and is used as a source of irrigation for the course. Only tees and greens are irrigated and these only through spring and summer months. The pond reportedly doesn't have a discrete piped outflow to control maximum level with water, instead dissipating through banked side walls. It is currently unclear as to the relationship between the pond water level and the non-pumping groundwater level.

Another area located directly east of Howth Golf Course is known as the King's Tank (see Envirologic (2020) for mapped location). This tank was presumably developed to collect and store potable rainwater for local residents/farms. The western end of the valley appears to have been deepened by excavation and a 7m high concrete wall cast to impound water. The eastern side of the excavation is steep and has been reinforced in places with dry stone walling. Water collected in a narrow valley channel to the east enters the eastern side of the excavation.

Between the golf course and Carrickbrack Road streamflow is within a steep, open channel with a rocky bed and is mostly inaccessible due to scrub encroachment. The channel is culverted between houses on the northern side of Carrickbrack before flowing through grassland fields used for grazing horses on the southern side. A pond (referred to as the The Cliffs Farm Pond) occurs by the edge of this field, which is D-shaped and contains a small island.

The stream dimensions become wider as the hydraulic gradient flattens out approaching the northern foot of an east-west raised ridge. The stream then flows east alongside an internal access road and cascades over a 400 mm wide weir-top in a stone wall before turning south. Localised flooding has reportedly occurred previously in this area. The stream continues southwards along the eastern side of a private laneway in a constructed channel before flowing through a grassland pasture. A spring seep in this area is apparent due to wet grassland though this appears to be shallow groundwater accumulating on the upgradient side of a boundary wall.

Immediately upgradient is a dry valley feature (see Envirologic (2020) for mapped location), currently dry woodland, and this is potentially the original Balsaggart Stream route. This theory is reinforced by the unnatural hydromorphology of the current stream route downgradient of this area. The dry valley may be a glacial feature, with a more natural outfall landscape evident along the coast 300 m northwest of the current outfall, where relatively low flow of surface water (1.5 l/s) was noted. The stream is bridged over a public walking trail and subsequently outfalls to the sea over a rocky shore at Dublin Bay on the southern edge of Howth Head. Ongoing complaints exist with regard to an untreated sewage outfall into Dublin Bay. Remedial works are currently ongoing.

4.9.3 Vegetation Description

The aforementioned pond on Howth Golf Course mostly consists of open water with more or less no aquatic plant vegetation, however, it also has a small, dense, species-poor reed and large sedge swamp (FS1) bed dominated by *Typha latifolia* (Bulrush) and *Equisetum fluviatile* (Water Horsetail). This is most comparable to the *Phragmites australis – Typha latifolia* swamp (FW3B) community, although this *Typha*-dominated form (with no *Phragmites australis* (Common Reed) present) needs to be updated as a new swamp community (P. Perrin, pers. comm., November 2020). Another area located directly east of Howth Golf Course is known as the King's Tank (Envirologic, 2020); however, this area was not successfully accessed for a botanical survey during the present surveys. Therefore, it was not possible to confirm whether there is any existing wetland vegetation within this tank, other than scrub.

The depositing/lowland river (FW2) habitat itself contains a few different vegetation communities of note. The most common community within the stream is the *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E), which dominates most of the streams on Howth Head. This community is characterised by the abundant and constant presence of both *Helosciadium nodiflorum* (Fool's-water-cress) and *Nasturtium officinale* agg. (Water-cress), often alongside grass species such as *Agrostis stolonifera* (Creeping Bent) and *Phalaris arundinacea* (Reed Canary-grass). The presence of these constant species indicates that the water is likely quite base-rich and nutrient-enriched. A pond (referred to as the The Cliffs Farm Pond/wetland) occurs by a field located directly south of Carrickbrack Road; however it was not possible to safely access and survey this area . In addition, dense scrub surrounding the pond impeded any study from a distance. A small artificial island occurs within the pond itself.

Dry woodland is present along the banks of the stream (at relevé AFHowthR_10) north to its outlet into Dublin Bay. At this location, another aquatic plant community can be found, namely the *Rhynchostegium riparioides – Chiloscyphus polyanthos* aquatic community (FW2B). This species-poor, bryophyte-dominated community generally occurs in "*fairly fast-flowing, shaded, mesotrophic rivers and streams*" (NBDC, 2020). *Rhynchostegium riparioides* is the only constant species in this community. Other species may also occur, including *Conocephalum conicum, Cratoneuron filicinum* and *Pellia endiviifolia* on shaded wet rocks, as is the case at this site. This community may be negatively affected by "*eutrophication, acidification, river engineering and trampling from livestock with access to the bankside. Removal of bankside tree cover may impact upon shade-loving bryophytes*" (NDBC, 2020). The non-native species *Sasa palmata* (Broad-leaved Bamboo) was found spreading along the wooded stream banks. This species may become invasive in this area if left to spread in an uncontrolled fashion. It is not on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011.

Ornamental ponds also occur in this aforementioned woodland (referred to as The Cliffs Ornamental Ponds), the water having been diverted from the stream itself through the ponds. The vegetation community in these ponds is largely also made up of the same *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E); however with a surprising abundance of *Caltha palustris* (Marsh-marigold). This species may be introduced here.

Wet grassland (GS4) habitat can also be found associated with the stream. The communities that exist include *Juncus effusus – Rumex acetosa* grassland (GL2D) (*e.g.* at relevé AFHowthR_30). This community is characterised by the presence of abundant and well-grown *Juncus effusus* (Soft Rush), along with the frequent presence of such species as *Ranunculus repens* (Creeping Buttercup) and *Rumex acetosa* (Common Sorrel). This is a generally species-poor grassland community of low conservation value (NBDC, 2020). Also present here (*e.g.* at relevé AFHowthR_31) is *Juncus effusus – Holcus lanatus* grassland (GL2B). This community is characterised by the presence of abundant *Juncus effusus* (Soft Rush), along with the frequent presence of such species as *Ranunculus repens, Holcus lanatus* (Yorkshire Fog)*, Agrostis stolonifera* (Creeping Bent)*, Anthoxanthum odoratum* (Sweet Vernal-grass)*, Ranunculus acris* (Meadow Buttercup)*, Cirsium palustre* (Marsh Thistle) and *Juncus acutiflorus* (Sharp-flowered Rush). This is also a generally species-poor grassland community of low conservation value (NBDC, 2020).

4.9.4 Threats and pressures

Scrub encroachment and the spread of invasive species in these habitats are primary threats. Furthermore, changes to upstream water sources in Howth Golf Club and culverting and increased drainage associated with other local developments are effecting the water flow of the stream. Eutrophication arising from upstream activities may also threaten these wetlands.

4.9.5 Recommendations

1. **Explore the feasibility of raising the outlet of King's Tank to impound a small amount of water. Conduct botanical survey on the tank floor. It is important to preserve this feature as there is evidence of it being of local water engineering heritage.**
2. **Contributing catchment of the pond require further clarification. Confirm catchments to inflows via more detailed walkover survey of drainage network.**
3. **Discuss and review groundwater pumping regime with Howth Golf Club in order to better manage the water sources in the area for biodiversity. Consider long-term water level monitoring in the pond.**
4. **Consider commissioning a small project to assist groundsmen at Howth Golf Club in the development of a course drainage map.**
5. **Sample stream downgradient of Howth Golf Course. Include in the sampling parameters to assess use of fertilisers, pesticides and/or herbicides. Assess bacteria in order to measure efficacy of biocycle and percolation at inner course toilet of Howth Golf Course.**
6. There is some diffuse upwelling of water to the rear of 'Well House' (see Figure 16), as well as ponded areas and very slight foul smell, which may be leading to nutrient enrichment of local water supply. Complete walkover survey and door-to-door discussions to ascertain source of malodour. Complete surface water sampling on stream to identify contaminants. Potential sample points include road crossing and cascade at southern end of laneway junction at eastern end of farm.
7. **Clearance of scrub around The Cliffs Farm Pond at edge of farmland field may be required in order to provide better access for surveying. Survey size and levels of island within the pond. Follow-up botanical survey of this pond is required as field could not be safely accessed on day of survey.**
8. Restrict livestock access into the stream. Install drinkers as an alternative source of water for livestock.
9. If required in the future, there is the possibility of adjusting inflow and outflow pipe levels to raise water levels in The Cliffs Ornamental Ponds. This is presently not deemed necessary, as siltation is not currently excessive in the ponds.
10. Follow up botanical survey on dry (possibly glacial) (see Figure 16) valley which runs east towest directly north of The Cliffs Ornamental Ponds. There is some evidence to suggest that this may have been the original natural route of Balsaggart Stream.
11. Intermittent scrub clearance in certain sections in order to open up and develop the stream and stream bank wetland vegetation, *e.g.* on slope south of Howth golf course (in winter and all cuttings should be removed from the site).
12. Monitor population of non-native *Sasa palmata* along the stream banks and control when necessary.

Figure 16 Balsaggart Stream (Site 9) map.

Plate 28 Relevé AFHowthR_10 in Site 9: Rhynchostegium riparioides – Chiloscyphus polyanthos aquatic community (FW2B).

Plate 29 Relevé AFHowthR_11 in Site 9: Apium nodiflorum – Rorippa nasturtium-aquaticum agg. aquatic community (FW2E).

Plate 30 Other artificial lakes and ponds (FL8) habitat linked to Balsaggart Stream site (Site 9) – location of Relevé AFHowthR_9: Apium nodiflorum – Rorippa nasturtium-aquaticum agg. aquatic community (FW2E)), with an abundance of Caltha palustris (Marsh-marigold).

4.10 Site 10 – Bloody Stream Catchment

4.10.1 Overview

The Bloody Stream is a relatively short stream which originates on high ground at Muck Rock near the Howth Reservoir in Deer Park golf course in the north-west of Howth Head and flows in a northerly direction to the coast where it discharges into the Irish Sea. In historic maps (including the historic six inch colour maps from 1837-1842), the Bloody Stream follows more or less the same course as it does today, flowing in a northerly direction through the whole of the present Deer Park golf course, rising in the area of today's Howth Reservoir. This stream has been heavily culverted and/or deepened along much of its course, although the overall route of its course has changed little from the 1800s. As a result of these changes, today the stream itself holds very little wetland vegetation. Nonetheless, in the area located directly east of Howth Castle where the stream is impounded by a concrete wall, a pond known as Black Jack's Pond has developed. This pond is present on the early 1837-1842 maps (see Figure 19). Furthermore, another pond known as Swan Pond was constructed directly west of Howth Castle. The Howth Reservoir itself was originally constructed to provide potable and irrigation water supply to the Howth Castle Demesne. It is not present on the 6 inch or 25 inch historic (OSI) maps, however, an area referred to as "*Ballykill Bog*" (see Figure 18) is shown at this location on the 6 inch Cassini maps, and a wet area is also shown on the 25 inch historic maps. This site (which includes the Bloody Stream, Howth Reservoir and Howth Castle ponds) is currently ranked as the seventh most important botanical wetland site on Howth Head due to its associated pond vegetation, and the potential for restoration which is presented by the Bloody Stream (see Table 2).

4.10.2 Hydrology

The Bloody Stream catchment commences on the raised ground at Muck Rock. The primary inflow to the stream is the outflow from Howth Reservoir, after which the stream is culverted for 500m as it flows northwards. Other inflows include:

(i) runoff and subsurface drainage from the greenfield area within Deer Park estate to the east of the stream;

(ii) runoff and subsurface drainage from the agricultural grassland field directly south of the Castle

(iii) hardstanding runoff from Deer Park Hotel, car park and internal access road.

The limited open channel section of the Bloody Stream commences in the wooded area on the eastern side of the laneway between Howth Castle and Deer Park Hotel. At the front of Howth Castle the stream tapers off into Black Jack's Pond. Approximately 70m downstream of the pond the stream disappears underground through a small clay berm, it being assumed that there is a collapsed culvert structure beneath/behind the berm; however, this was not observed. It is clear that when this structure gets inundated water levels quickly reach 1m depth, reportedly flowing across the surrounding area before re-entering the culverted channel at an unidentified point downstream. A 600 mm culvert within a brick-built 2m deep underground chamber was observed approximately 15m south of the Howth Road. The culvert outfalls at a clearly visible cascade on the southern road embankment before re-entering a culvert which transmits water to its final outfall on Claremont Beach. The Howth Reservoir itself was originally a holding pond used to store water for potable and irrigation supply to Howth Castle Demesne. The reservoir likely also serves to attenuate flashy runoff from raised ground to south following heavy rainfall. The perimeter of the reservoir is defined by a raised embankment. Inflow into the reservoir is via diffuse runoff from Greenhollows area and a discrete outflow from Bog of Frogs merge at a confluence 100m south of reservoir, before entering a 200mm concrete culvert. This culvert enters on the southern side of the reservoir. Separately, water collected at the toe-slope of raised ground directly south of Beann Eadair GAA club grounds is transmitted in an east-west open drain which is diverted to the south-eastern corner of the reservoir. Inflows from the woodland area to the west appear to be diffuse but closer inspection is required to confirm this. The outflow is at the north-western corner of the reservoir, and the main pipe from the reservoir sluice flows directly north and forms the headwater of the Bloody Stream.

4.10.3 Vegetation Description

There is more or less no existing wetland stream vegetation within the Bloody Stream FW2 habitat (nor indeed in the associated FW4 drainage ditches) itself, unlike most of the other streams on Howth Head, which indicates how poor the condition of this stream is currently.

The most notable vegetation in this site can be found in the associated ponds, in particular, Black Jack's Pond. This pond contains both reed and large sedge swamps (FS1) and tall-herb swamps (FS2) vegetation. The FS1 vegetation is largely dominated by *Typha latifolia* (Bulrush). This is most comparable to the *Phragmites australis – Typha latifolia* swamp community (FW3B), although this *Typha*-dominated form (with no *Phragmites australis* (Reed) present) needs to be updated as a new swamp community (P. Perrin, pers. comm., November 2020). The FS2 vegetation is largely dominated by *Epilobium hirsutum* (Great Willowherb) and *Nasturtium officinale* agg. (Water-cress). The vegetation communities within the pond include the *Eleocharis palustris – Agrostis stolonifera* marsh/fen (FE3C) community (relevé CCHowth_R8). This marsh community is quite varied in herbaceous grass, sedge and forb species, which may include *Eleocharis palustris* (Common Spike-rush)*, Agrostis stolonifera* (Creeping Bent)*, Mentha aquatica* (Water Mint)*, Helosciadium nodiflorum* (Fool's-water-cress), *Nasturtium aquaticum* agg. and *Juncus articulatus* (Articulated Rush). Also in this pond and on its margins, *Holcus lanatus – Lolium perenne* grassland (GL2C) occurs (relevé CCHowth_R7), which is a relatively species-poor community of low conservation value, often dominated by *Holcus lanatus* (Yorkshire Fog), *Agrostis stolonifera* (and *Lolium perenne* (Perennial Ryegrass) in the more improved examples, not found here), along with *Ranunculus repens* (Creeping Buttercup) (NBDC, 2020). The relatively frequent *Apium nodiflorum – Rorippa nasturtium-aquaticum* agg. aquatic community (FW2E) also occurs in the pond.

Swan Pond has a little wetland vegetation developed within it or along its banks, however, *Potamogeton natans* (Broad-leaved Pondweed) does occur abundantly in its waters, and *Alisma plantago-aquatica* (Water-plantain) occurs by its banks. The former aquatic plant community is comparable to the *Potamogeton natans – Equisetum fluviatile* aquatic community (FW3J), which has *Potamogeton natans* as its only constant species, sometimes alongside *Equisetum fluviatile* (Water Horsetail) and *Nymphaea alba* (White Water-lily) (NBDC, 2020). The aquatic vegetation of Howth Reservoir is very sparse and species-poor. The dominant species in much of the reservoir is the invasive non-native species *Elodea canadensis* (Canadian Waterweed), along with a good quantity of surface algae. This invasive species is on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011. The vegetation here is considered as being of low conservation value.

4.10.4 Threats and pressures

The Bloody Stream is primarily threatened by continued changes to upstream water sources in the Deer Park golf course (including potential future development works in the area, specifically altered contributing catchment, increased hardstanding area, altered subsurface drainage network), as well as the culverting of entire portions of the stream (with old subsurface drainage infrastructure within Howth Demesne, which has been altered at various intervals in the past). There is almost no existing wetland stream vegetation within the course of the stream itself, which is indicative of the very poor ecological status of this stream. The ponds themselves are threatened by continued organic sediment deposition, which is resulting in the drying out the vegetation. Eutrophication caused by upstream water inputs from the golf course may also threaten these wetlands.

4.10.5 Recommendations

Black Jack's Pond (located directly east of Howth Castle):

1. **Dredge the inflow area to the pond. Consider altering the stream bed to dampen flow velocities on approach and installing an inlet structure with an overflow that would allow sediment to settle out of solution and be removed regularly. This would provide a more confined chamber for entrapping and removal of sediment/debris.**

2. Consider dredging the entire pond. This would facilitate a more suitable target depth of water for particular species, shelfing within pond, and would also increase attenuation capacity. There is an estimated 1 m of sediment in the downstream (northern) end of the pond.
3. Remove fallen trees from impoundment walls to prevent structural damage of pond.
4. **Considering repairing the breach on eastern side of pond impoundment wall. This would raise pond water levels by 1m (if considered desirable).**
5. **Repair sluice in impoundment wall to complement recommendation 4 above. Calibrating the sluice would enable the pond to attenuate higher inflows. Similar rehabilitation of the two downgradient dam walls would allow targeted water depths in the stream intervals which could be used to promote different wetland plant species/vegetation.**

Bloody Stream:

1. **Consider the feasibility of de-culverting (particularly the northern) culverted sections of the Bloody Stream, *e.g.* north of the Black Jack's Pond and impoundment area.**
2. **Consider the feasibility of raising the channel bed of the Bloody Stream in the deepened sections, particularly the area south of Black Jack's Pond.**
3. Some undermining of stream banks upgradient of pond. Reinforcement works not considered urgent; however, a biannual inspection and maintenance programme is recommended.
4. **Further investigate the buried culvert inlet *c.* 70m downstream of the pond. In order to better ascertain the current stream water management regime in this area.**
5. **Consider commissioning a small project to assist groundsmen at Howth Demesne to develop a current drainage map.**
6. Reinforcement works on stream banks not considered urgent but a biannual inspection and maintenance programme regarding structural integrity recommended.

Howth Reservoir:

1. Install water level logger to confirm degree of water level fluctuation in reservoir. This is important to better understand maximum potential release of uncontrolled water in event of sluice failure.
2. Perform inspection of sluice mechanism to confirm invert level of reservoir.

Swan Pond:

1. Preserve this pond in its current form. Consider dredging of pond in the future if organic sediment accumulation becomes excessive.

Figure 17 Bloody Stream and Howth Castle ponds (Swan Pond in the west and Black Jack's Pond in the east) (Site 10).

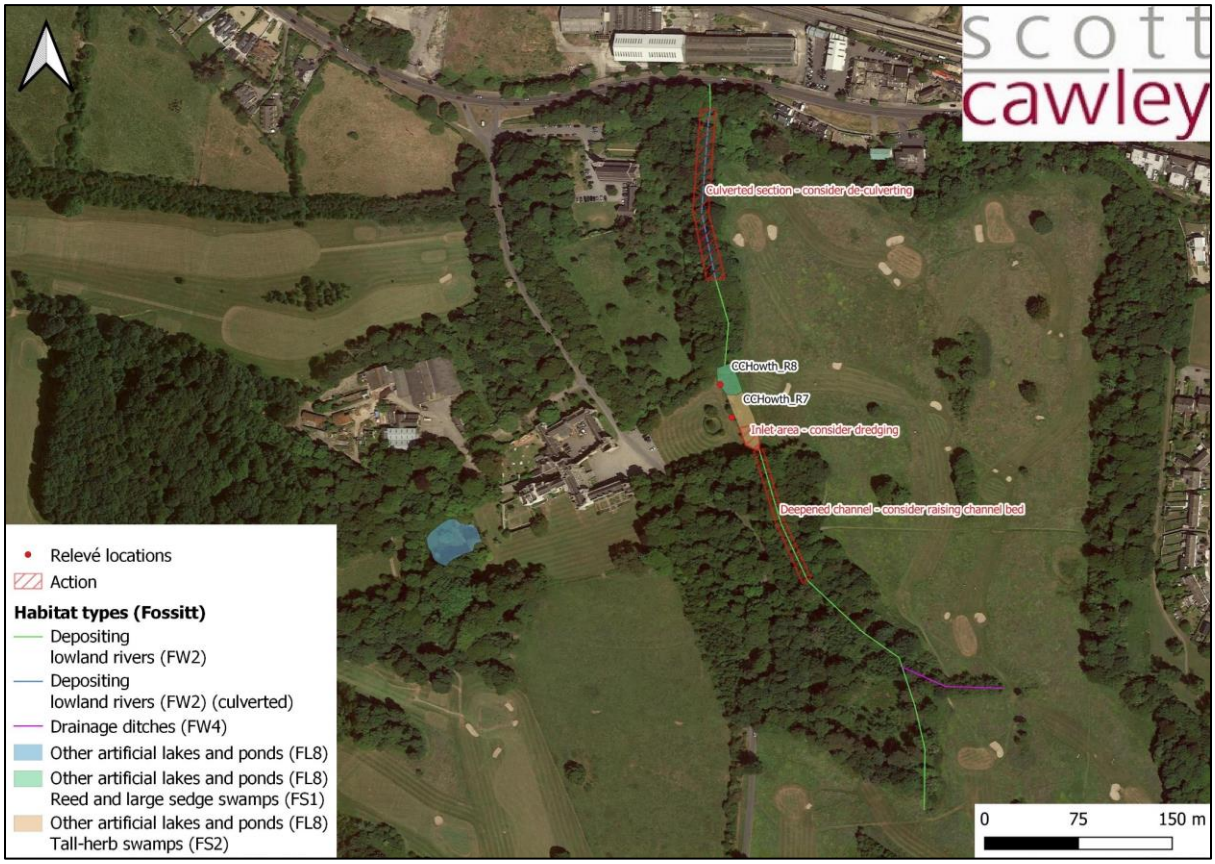


Figure 18 Howth Reservoir (Site 10) – also including former course of Bloody Stream and probable former wetland ("Ballykill Bog") site prior to construction of Howth Reservoir (from historic 25 inch maps from 1888-1913).

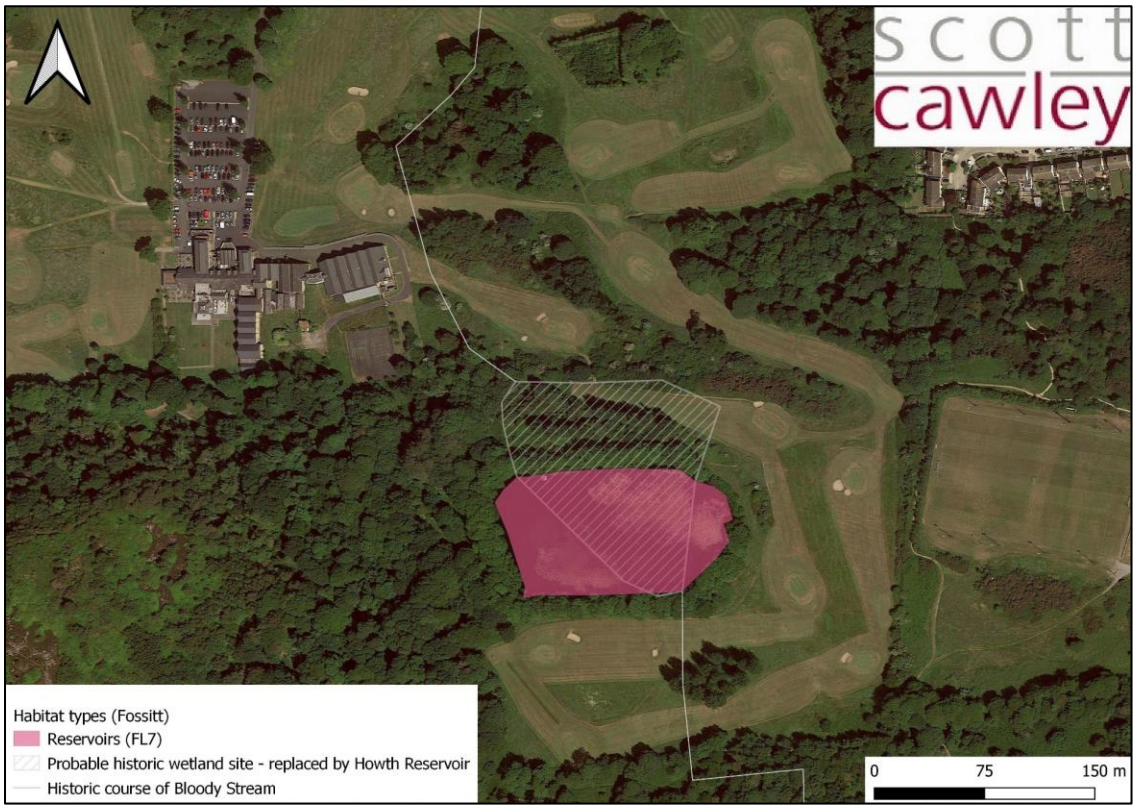


Figure 19 Howth Castle, Fish Pond (i.e. Black Jack's Pond) and Swan Pond visible on the historic six inch colour maps from 1837-1842 © Ordnance Survey Ireland

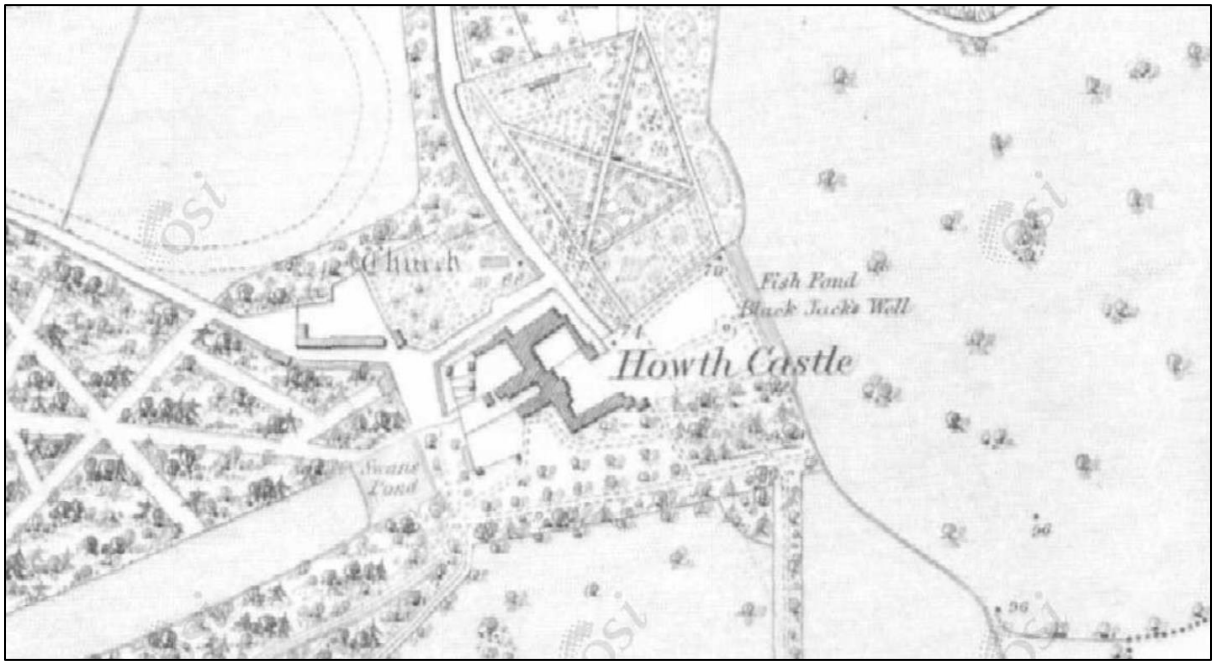


Plate 31 Swan Pond, just west of Howth Castle.

Plate 32 Black Jack's Pond, just east of Howth Castle (location of Relevés CCHowth_R7 & CCHowth_R8).

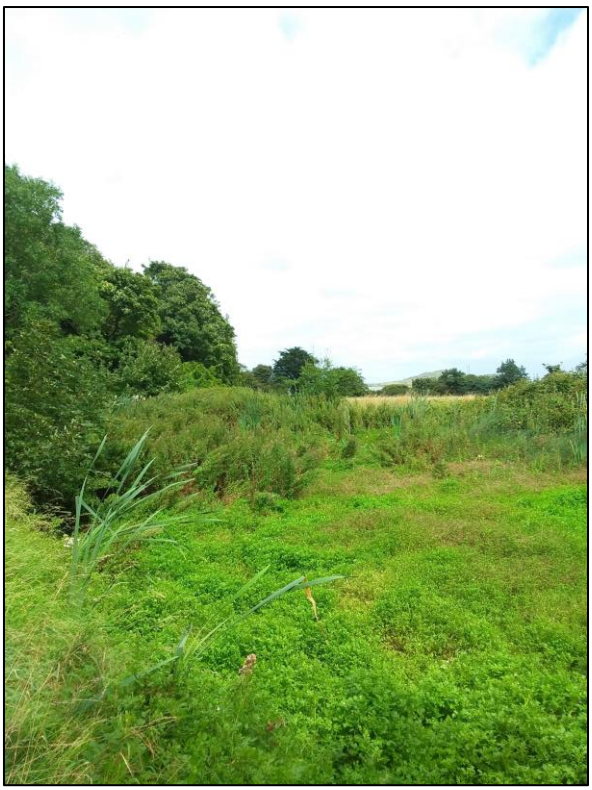
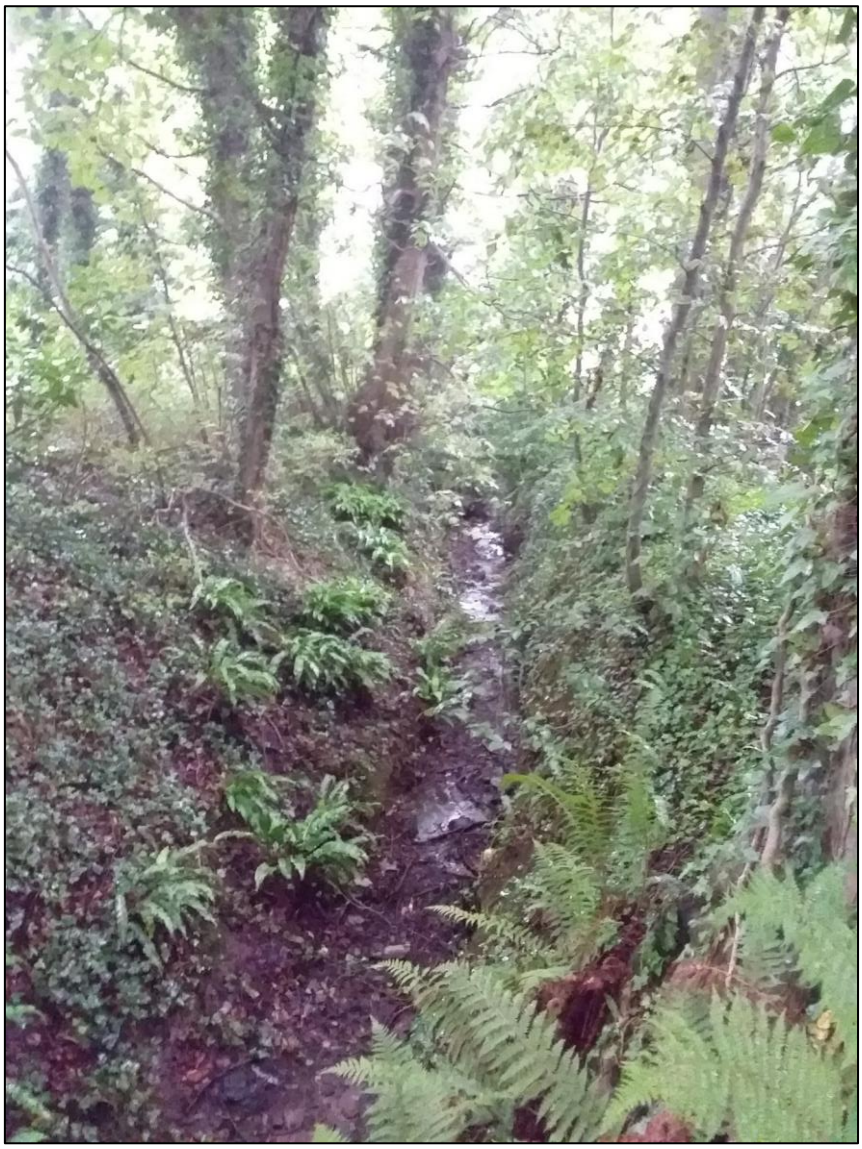


Plate 33 Bloody Stream, just south of Black Jack's Pond – deepened stream course, with little or no wetland vegetation present. Dry woodland vegetation occurs on the stream banks.



4.11 Site 11 – Nose of Howth

4.11.1 Overview

At this site, wetland vegetation occurs in a very scattered distribution mostly along the Howth Cliff Walk pathways in the areas located south and east of Kilrock in north-east Howth Head. This distribution of wetland vegetation at this site indicates the location of two minor streams in the area, known as the Eastern Stream (flows towards the eastern margin of the Nose of Howth) and the Northern Stream (flows towards the northern margin of the Nose of Howth). These streams generally have weak/intermittent flow in an area which is largely dominated by scrub, heath and rocky outcrops. There is no indication of Northern Stream on historic maps, however, the Eastern Stream is visible in essentially the same course on the historic 25 inch maps (see Figure 22). Scattered wet grassland vegetation mostly indicates the presence of these stream flows. Furthermore, a (presumably artificial) pond habitat also occur at the southern end of the site. This site is currently ranked as the tenth most important botanical wetland site on Howth Head due to the limited stream, wet grassland and pond vegetation occurring in the area(see Table 2).

4.11.2 Hydrology

The scattered wet grassland vegetation at this site is largely fed by minor streams/water channels, some of which follow the course of the walking paths in the area. The Eastern Stream appears to rise from a site of ruins located *c.* 150m east of Cannon Rock Cottage and within a horseshoe-shaped depression at the base of a raised bedrock exposure. A well is indicated at this location on historic 25 inch OSI maps. The stream runs through a shallow valley which drains a relatively small catchment in the north-eastern corner of the peninsula. This is a typical example of the many small catchments on East Mountain which drain to the coast. The channel then runs through or around a small area of *Betula* (Birch) trees before turning east where it flows freely over the path. This can promote erosion through the hard rock; however, this is unlikely to be a significant issue at this location due to the small stream dimensions. The stream is culverted beneath the lower cliff path via a 200mm PVC pipe and outfalls to the sea through a steep, narrow gorge on an east facing cliff.

The Northern Stream flows north through the site and crosses the public walking pathway about midway along its route. From this location water flow is confined to the walking pathway and continues along this route until close to the main Howth Cliff Walk pathway (concretised) crossing to the north. The path which the stream flows along is not the lowest route in the vicinity which suggests that the natural drainage route has been blocked or obstructed. The natural flow is more likely to be the steep vegetated valley (see Figure 20) to the immediate west, or a *c.* 4m deep, north-facing, horseshoe-shaped depression which appears to be a small quarry excavation. Flow from the path enters a small depression immediately upgradient of the main walking trail to the north. The stream then flows through a stone-built channel recently installed on the Howth Cliff Walk pathway before out-falling to the sea through a steep, narrow gorge on a north facing cliff.

The pond in the south of the site is presumed to be artificial in nature, as it does not occur on any of the notable historic maps (this pond is addressed by Envirologic (2020) as part of Site 6 – referred to as the Upper Cliff Road Pond). There are no discrete inflows. Direct rainfall and runoff from a small area of exposed bedrock supply the pond, and its hydrological connection with Cowbooter Lane and Coulcoor Brook has not been confirmed.

4.11.3 Vegetation Description

The wetland vegetation in this site is predominantly made up of wet grassland (GS4), which indicate the flow of the streams throughout the site. Much of this wet grassland is drying out (perhaps indicating disruptions/changes to water flow rate and direction) and is represented by *Holcus lanatus – Lolium perenne* grassland (GL2C), which is a relatively species-poor community of low conservation value, often dominated by *Holcus lanatus* (Yorkshire Fog)*, Agrostis stolonifera* (Creeping Bent) and *Lolium perenne* (Perennial Ryegrass), along with *Ranunculus repens* (Creeping Buttercup), *Trifolium repens* (White Clover), *Cerastium fontanum* (Common Mouse-ear), and in this area, often a significant presence of *Epilobium*

hirsutum (Great Willowherb) (NBDC, 2020). The wet grassland associated with the Eastern Stream is considered to be mostly *Agrostis stolonifera – Ranunculus repens* marsh-grassland (GL2A), which as the name suggests is dominated by *Agrostis stolonifera* along with with *Ranunculus repens, Galium palustre, Potentilla anserina, Calliergonella cuspidata* and other species. It is a relatively species-poor community which is generally managed through rough grazing, but not in this case, and therefore, scrub encroachment is an issue here. The main threats to this community are grassland improvement, abandonment and changes to flooding regime (NBDC, 2020). The wet grassland by the pond at the south of the site (see Figure 21) consists of *Juncus effusus – Rumex acetosa* grassland (GL2D). This community is characterised by the presence of abundant and well-grown *Juncus effusus* (Soft Rush) along with the frequent presence of such species as *Ranunculus repens* (Creeping Buttercup). The two streams are very overgrown with scrub (WS1) and *Pteridium aquilinum* (Bracken) and have little if any well-developed (and accessible) stream vegetation within them.

4.11.4 Threats and pressures

Scrub and *Pteridium aquilinum* encroachment on the streams is a primary threat, whilst in the other scattered areas of wet grassland, diversion of upstream water sources (*e.g.* for the pasture fields to the west) is a threat. Eutrophication caused by upstream water inputs from pasture fields may also potentially threaten these wetlands.

4.11.5 Recommendations

1. **Consider feasibility of digging holes/ponds in areas of wet grassland vegetation in order to better access the water table (see Figure 20).**
2. **Intermittent physical cutting of scrub (*e.g.* dense *Rubus fruticosus* agg.) (in winter and all cuttings should be removed from the site) and *Pteridium aquilinum* (cutting twice per year, at start and end of summer and all cuttings should be removed from the site) along portions of the short stream in order to improve the species-richness of the stream bank and other wetland vegetation in this area. No herbicide should be used for this purpose. Also physical removal of scrub from the sources of both streams would be advisable, in order to better ascertain their sources.**
3. Install culvert or raised path/boardwalk section to prevent stream bed and bank erosion where streams cross walking pathway.
4. Consider diverting Northern Stream flow away from walking pathway and into the narrow valley to the immediate west of the pathway.

Figure 20 Eastern Stream, Northern Stream and wet grassland habitats at the Nose of Howth (Site 11).

Figure 21 Pond at the Nose of Howth (Site 11).

Figure 22 Eastern Stream at the Nose of Howth, from the historic 25 inch colour maps from 1888-1913 © Ordnance Survey Ireland.

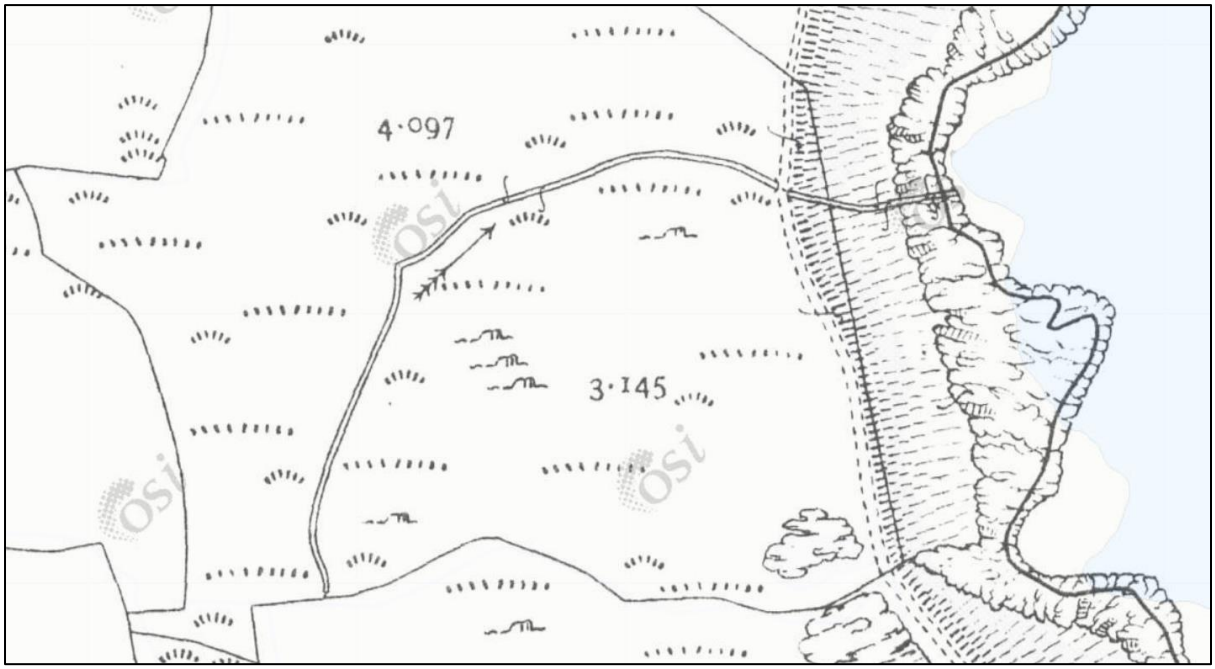


Plate 34 Relevé AFHowthR_27 in Site 9: Holcus lanatus – Lolium perenne grassland (GL2C).

Plate 35 Relevé AFHowthR_28 in Site 9: Agrostis stolonifera – Ranunculus repens marsh-grassland (GL2A), by the Eastern Stream.

Plate 36 Perpendicular drains installed in concretised walking pathways.

4.12 Site 12 – Sutton Golf Club Ponds

4.12.1 Overview

Sutton Golf Club is a private golf course in Sutton (in the north-western section of Howth Head) that was established in *c.* 1890 on a large sand spit which extends into the Irish Sea by the estuary of the Sluice River, opposite Portmarnock strand. This area is referred to as "*The Cosh*" in many older sources, including Hart (1887). Four ponds in total occur within the portion of the golf course that is in the study area, and these constitute the only wetland features in this site. The southern three ponds are aligned along the route of an historical drainage channel shown on the historic 25 inch maps from 1888-1913.Three of these ponds are predominantly freshwater, whilst one of them (the south-westernmost pond) has a strong brackish water influence and contains salt-marsh/lagoon type vegetation. A further single pond (not visited during this survey) occurs outside of the study area boundary in the northern portion of the golf course (however it was assessed by Envirologic (2020)). This site is currently ranked as the twelfth most important botanical wetland site on Howth Head due to the fact that the only wetlands in the site are newly constructed, artificial (not semi-natural) ponds (see Table 2).

4.12.2 Hydrology

The main inflows to the ponds are from the surrounding subsurface drainage network (groundwater). The ponds were previously used as an irrigation supply for the golf course, however, this practice was largely ceased due to the small pond size and the susceptibility of the water to experience saline intrusion. However, the northern pond is still used as a primary irrigation supply for the northern golf course during prolonged dry weather. In the case of high water levels in the ponds due to higher than normal groundwater flow, the excess water is pumped to the western estuary. Liquid seaweed fertiliser is used for the ponds generally, with a 2m buffer applied to the ponds, and weedkiller is used sparingly, again with a 2m buffer applied to the ponds. Previous attempts to source groundwater irrigation supply from a bedrock aquifer proved unsuccessful.

The easternmost and central ponds in the south of the site are connected via a subsurface pipe installed 2 m below the intervening green. A recently installed concrete channel at the eastern end of the easternmost pond becomes active when pond water levels exceed 1.26 mOD. A 30mm pipe at the south-eastern end of the channel acts as an overflow outlet. This reportedly transmits excess water to a flood relief pipe recently installed by the local authority along the right of way south of the ponds. This pond was emptied and cleaned to facilitate installation of the flood relief channel. The south-westernmost pond is in direct contact with saline waters, as shown by conductivity measurements. A 300mm pipe at the eastern end of this pond provides direct connectivity with the estuary to the west. A sluice flap is in place at the pipe outlet; however, it may have failed.

4.12.3 Vegetation Description

The south-westernmost pond in the site contains, unlike the other three, a pronounced brackish water influence, and as a result, a salt-marsh type of vegetation has developed in it. Although artificial, the pond water and vegetation mimics that of a lagoon. Two salt-marsh vegetation communities were present in the relevés, namely, *Festuca rubra – Agrostis stolonifera* saltmarsh (SM4A) and *Festuca rubra – Plantago maritima* saltmarsh (SM4D). However, salt-marsh habitat was not mapped or assessed further for this study.

The three other ponds were dominated by reed and large sedge swamps (FS1) vegetation on their banks. They are predominantly freshwater, although the typical salt-marsh-associated species *Bolboschoenus maritimus* (Sea Club-rush) does occur to some extent in all of these ponds, which could potentially lend the description of this vegetation to the *Bolboschoenus maritimus – Agrostis stolonifera* saltmarsh-swamp community, SM6A. Most of the ponds have little or no aquatic vegetation within them, with the exception of the easternmost of the three southern ponds, which had an abundance of *Potamogeton natans* (Broad-leaved Pondweed), as well as an unidentified charophyte species. This aquatic vegetation is comparable to the *Potamogeton natans – Equisetum fluviatile* aquatic community (FW3J), which has *Potamogeton natans*

as its only constant species, sometimes alongside *Equisetum fluviatile* (Water Horsetail) and *Nymphaea alba* (White Water-lily) (NBDC, 2020). The swamp habitat has some affinities to the *Schoenoplectus tabernaemontani* swamp community (FW3I), with its abundance of *Schoenoplectus tabernaemontani* (Grey Club-rush), along with lesser quantities of *Agrostis stolonifera* (Creeping Bent) and *Mentha aquatica* (Water Mint). *Typha latifolia* (Bulrush) is also a dominant species in much of the FS1 swamp areas surrounding the ponds. This is most comparable to the *Phragmites australis – Typha latifolia* swamp (FW3B) community, although this *Typha*-dominated form (with no *Phragmites australis* (Reed) present) needs to be updated as a new swamp community (P. Perrin, pers. comm., November 2020).

The large northern pond contains a small population of *Samolus valerandi* (Brookweed), which was recorded from the south shore of the pond. This was a re-find of Hart's record of this species from "*wet or damp places, chiefly by the sea…Sutton*" (Hart 1887). The species is today considered to be occasional in coastal wetlands in Dublin; however rare inland (Doogue *et al.,* 1998).

4.12.4 Threats and pressures

Few, if any, immediate threats to these ponds are currently envisaged. However, over time, the slow drying out of the ponds due to organic sediment accumulation may become a threat. Furthermore, eutrophication from the treatments used on the local golf course greens as well as toxic herbicide treatment in the area may also put pressure on these habitats.

4.12.5 Recommendations

1. **Consider constructing new and larger ponds near to existing ponds (and/or connecting existing ponds via channels) to increase available wetland habitat. Consider creation of further artificial lagoon-type habitat utilising brackish water influence.**
2. Consider dredging of existing ponds if/when they become choked with organic sediment.
3. Monitor the ponds on an ongoing basis in terms of surface water quality.

Figure 23 Sutton Golf Club (Site 12) map.

Plate 37 Brackish pond in Sutton Golf Club (site 12), with salt-marsh/lagoon vegetation.

5 Historical Analysis of Wetlands on Howth Head – Primary Drivers of Change and Loss

The study area for this survey consists of the entire peninsula of Howth Head, with a focus on all known and potential wetland habitats which may occur here. One SAC is located within this study area, namely, Howth Head SAC, which overlaps with the pNHA of the same name. The entire study area is also contained with the Howth Special Area Amenity Order, which affords special protection for the heritage and semi-natural habitats of this area within Fingal County Council.

The study area harbours an array of different wetland habitats, vegetation communities and rare plant species, which have been elucidated in detail in this report. 12 core sites were investigated in detail and botanical data was collected at 4m^2 relevé in order to identify and confirm the vegetation communities present within wetland habitats at these sites according to both Fossitt (2000) and the Irish Vegetation Classification (IVC) system (NBDC, 2020). This site-based survey will inform continued efforts to conserve and restore the various wetland habitats and sites of Howth Head, which have suffered considerable losses in recent decades, due to a number of man-made and natural processes. These process relate to drainage (associated with housing developments and maintenance of golf course), scrub encroachment, eutrophication, habitat removal and invasive species spread. Important restoration measures in these sites will include the re-establishment of their natural hydrological dynamics through various environmental engineering strategies, as well as active and repeated clearing of scrub and invasive species and pond creation, amongst other measures.

The wetlands of Howth Head have undoubtedly changed and reduced significantly over the last few centuries, and this change and loss has only accelerated in more recent decades. The threats and pressures which effect wetland habitats on Howth are ones which are familiar in many wetland habitat conservation contexts across Fingal County Council, and indeed across all of Dublin and Ireland. They include both natural and man-made threats and pressures.

The natural threats and pressures which are suffered by Howth Head wetlands include scrub encroachment. This is of particular concern in the Whitewater Brook (Site 4) and Bog of Frogs (Site 3) sites. Invasive alien species are most prevalent as pressures in the Offington Wetland (Site 8), Greenhollows (Site 2) and Whitewater Brook (Site 4) sites, and can often be introduced to a site as a result of illegal dumping of garden waste or by deliberate introduction of non-native species which later becomes invasive. In the former site, the slow drying out of the pond has created an opportunity for invasive tree species such as *Acer pseudoplatanus* (Sycamore) and grassland species such as *Cortaderia selloana* (Pampas-grass) to establish. In Greenhollows, the scrubby, damp and acidic ground is highly amenable to the spread of the invasive species *Rhododendron ponticum* (Rhododendron). Although recent removal works of this species have been carried out here, further removal is required to eradicate it completely from the site. Finally, in the Hilltop House pond linked to the Whitewater Brook, introduced non-native species have become invasive there, including *Lysichiton americanus* (American Skunk-cabbage), *Gunnera tinctoria* (Giant-rhubarb) and *Rhododendron ponticum*.

The man-made threats and pressures which are suffered by Howth Head wetlands include perhaps most importantly the diversion of water sources and drainage. There is no better example of this than the Gray's Wood wet woodland site (Site 1). This was one of the most important wet woodland sites in the Fingal County Council area, until the construction of housing developments caused severe damage to the diffuse groundwater seepage and springs which provided this woodland with the continuous and organic wet conditions required for such a wet woodland to thrive. This has led to significant loss in the extent of wet woodland habitat present in recent years. The woodland continues to gradually dry out and become overtaken by scrub and dense rushy vegetation. Similarly, increasingly extensive drainage works related to the two main golf courses on Howth Head (Howth Golf Club and Deer Park Golf Club) have also led to increasingly channelised water courses, which may well have affected the quality of the Bog of Frogs (Site 3) and the Bloody Stream Catchment (Site 10). Pastural agriculture may have also negatively affected the wetlands at the Nose of Howth (Site 11).

Direct wetland habitat removal has also occurred extensively on Howth Head, particularly over the last century. This is most notably the case with the old 'quarry pit' wetland sites, which harboured significant wetland vegetation in the past (*i.e.* in the time of Hart (1887)), however, these habitats have now been

largely removed and built upon for housing and other developments. Habitat removal has occurred across large areas of the north of Howth Head.

These natural and man-made threats and pressures combined to drive the transformation and loss of local wetland habitats that have been known and studied by botanists for decades and centuries on Howth Head, stretching right back to the time of Walter Wade in the late 18th century.

Nonetheless, restoration measures may still be utilised to recover these wetland habitats and restore them to something which is closer to their former quality. These measures will include environmental engineering strategies, such as the re-engineering, de-culverting and filling in of drainage ditches and water channels/courses, the introduction of dams and sluice gates to slow water flow, the dredging of dried/drying wetland habitats and the creation of new pond habitats, as well as active and repeated management of scrub and invasive species which threaten wetland habitats over time. The protection and restoration of wetland sites on Howth Head will require concerted and consistent efforts from both Fingal County Council and other relevant stakeholders (including local residents) to manage these habitats so that both local communities and these wild habitats can thrive together in the future.

6 Priority Actions for Wetland Habitats on Howth Head

The following summary list of priority actions for wetland habitats on Howth Head is based upon an analysis of the estimated botanical importance of each site, as well as the considered urgency of each action, the feasibility of each action (local landowner co-operation and engagement being required in many sites) and the extent of positive impact which the action would likely produce for the wetland habitats and sites concerned. The summary list is as follows:

Site 1: Gray's Wood –

- Consider rewetting of the woodland via the installation of a sluice gate in the Bogeen Stream drainage channel located within the woodland to allow for re-wetting of the wet woodland habitat on occasion (action 1), and;
- Attempts could also be made to mimic the old spring-fed hydrogeological regime by attempting to re-distribute the channelised flow upgradient of the woods into a more diffuse pattern (action 2)

These restoration actions are urgently needed due to the rapidly deteriorating wetland habitat conditions on site, however, with the presence of nearby developments and existing residential housing, they will require co-operation and engagement from local landowners.

Site 8: Offington Wetland –

- Remove all invasive species from the site (action 2), and;
- Consider dredging northern pond (action 1)

These restoration actions (particularly action 2) are urgently needed due to the increasingly extensive populations of invasive species within the site, which is also linked to the drying out of the northern pond area (which itself may be solved by action 1).

Site 3: Bog of Frogs –

- Blocking the drainage channel at the eastern edge of the site (action 4), and;
- Physically pulling up *Betula pubescens* (Downy Birch) trees within the wetland using a digger and physically cutting back encroaching *Pteridium aquilinum* (Bracken) and *Rubus fruticosus* agg. (Brambles) scrub on an intermittent basis (action 7)

These restoration actions are urgently needed due to the rapidly deteriorating wetland habitat conditions on site.

Site 2: Greenhollows –

- Consider digging down into old quarry pit with historic *Eleogiton fluitans* (Floating Club-rush) population in an attempt to re-invigorate the plant here (action 2), and;

- Make further efforts to remove invasive species, particularly *Rhododendron ponticum* (Rhododendron), in the various wetland habitats on site (action 1)

Site 4: Whitewater Brook –

- Removal of invasive species within the water course (action 8), and;
- Restrict livestock access into the stream at the section where it flows through a field between Windgate Road and Carrickbrack Road (action 3)

Site 5: Kilrock Quarries –

- Physically clearing encroaching *Rubus fruticosus* agg. (Brambles) and *Ulex europeaus* (Gorse) scrub, particularly in the eastern and south-western (but also the northern) voids (action 1)

Site 10: Bloody Stream Catchment –

- De-culverting Bloody Stream section north of Black Jack's Pond (Bloody Stream action 1), and;
- Raising Bloody Stream channel section south of Black Jack's Pond (Bloody Stream action 2)

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Appendix I

Irish Vegetation Classification (IVC) communities per relevé (highlighted text corresponds to re-classification)

Relevé	Code	Site Code	Community	Group	Division
AFHowthR_1	FW2E	7	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_2	GL2D	2	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_3	GL1D-FE1A-GL2D	2	Molinia caerulea – Potentilla erecta – Agrostis stolonifera/Schoenus nigricans – Campylium stellatum /Juncus effusus – Rumex acetosa (reclassified from HE4D)		
AFHowthR_4	FW3E	2	Phragmites australis - Equisetum fluviatile	Phragmites australis - Cladium mariscus	Freshwater
AFHowthR_5	GL1A-GL2A	2	Juncus acutiflorus – Holcus lanatus/Agrostis stolonifera – Ranunculus repens (reclassified from SM6B)		
AFHowthR_6	FW2E	4	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_7	GL2C	4	Holcus lanatus - Lolium perenne	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_8	FE3C	4	Eleocharis palustris - Agrostis stolonifera	Agrostis stolonifera - Carex nigra	Fens and mires
AFHowthR_9	FW2E	9	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_10	FW2B	9	Rhynchostegium riparioides - Chiloscyphus polyanthos	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_11	FW2E	9	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_12	GL2C	[14]	Holcus lanatus - Lolium perenne (reclassified from None)		
AFHowthR_13	GL2D	1	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_14	FW3G	1	Equisetum fluviatile - Eleocharis palustris	Phragmites australis - Cladium mariscus	Freshwater
AFHowthR_15	GL2D	1	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_16	WL3B	1	Alnus glutinosa - Ranunculus repens	Alnus glutinosa - Filipendula ulmaria	Woodland
AFHowthR_17	GL2D	1	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_18	FW2E	7	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
AFHowthR_19	GL2C	6	Holcus lanatus - Lolium perenne	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_20	GL2A	6	Agrostis stolonifera - Ranunculus repens	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_21	GL2D	1	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_22	?FE3A	5	?Carex nigra – Ranunculus flammula (reclassified from None)		
AFHowthR_23	GL2A	5	Agrostis stolonifera - Ranunculus repens	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_24	GL1B	5	Agrostis stolonifera – Filipendula ulmaria (reclassified from GL3F)		
AFHowthR_25	GL2A	5	Agrostis stolonifera – Ranunculus repens (reclassified from SM6B)		
AFHowthR_26	GL2C	11	Holcus lanatus - Lolium perenne	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_27	GL2C	11	Holcus lanatus - Lolium perenne	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_28	GL2A	11	Agrostis stolonifera - Ranunculus repens	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_29	GL2D	[14]	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_30	GL2D	9	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
AFHowthR_31	GL2B	9	Juncus effusus - Holcus lanatus	Agrostis stolonifera - Ranunculus repens	Grasslands
CCHowth_R2	GL1A	3	Juncus acutiflorus - Holcus lanatus	Juncus acutiflorus - Molinia caerulea	Grasslands
CCHowth_R3	GL2D	3	Juncus effusus - Rumex acetosa	Agrostis stolonifera - Ranunculus repens	Grasslands
CCHowth_R4	GL1A	3	Juncus acutiflorus - Holcus lanatus	Juncus acutiflorus - Molinia caerulea	Grasslands
CCHowth_R5	FE3A	8	Carex nigra - Ranunculus flammula	Agrostis stolonifera - Carex nigra	Fens and mires
CCHowth_R6	GL2C	8	Holcus lanatus - Lolium perenne	Agrostis stolonifera - Ranunculus repens	Grasslands
CCHowth_R7	FW2E	10	Apium nodiflorum - Rorippa nasturtium-aquaticum agg.	Ranunculus pencillatus - Fontinalis antipyretica	Freshwater
CCHowth_R8	FW3G	10	Equisetum fluviatile - Eleocharis palustris	Phragmites australis - Cladium mariscus	Freshwater
CCHowth_R9	SM4D	12	Festuca rubra - Plantago maritima	Festuca rubra - Seriphidium maritimum	Saltmarsh
CCHowth_R10	SM4A	12	Festuca rubra - Agrostis stolonifera	Festuca rubra - Seriphidium maritimum	Saltmarsh
CCHowth_R11	GL3F	12	Festuca rubra - Lotus corniculatus	Cynosurus cristatus - Plantago lanceolata	Grasslands
CCHowth_R12	SM6A	12	Bolboschoenus maritimus - Agrostis stolonifera	Agrostis stolonifera - Juncus gerardii	Saltmarsh
CCHowth_R13	SM6A	12	Bolboschoenus maritimus - Agrostis stolonifera	Agrostis stolonifera - Juncus gerardii	Saltmarsh

Appendix II

All vegetation relevé data

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	129
Longitude	-6.06454300
Latitude	53.38077000
X-coordinate	-604790.000
Y-coordinate	660039.000
Releve reference	AFHowthR_1
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	50.000000 %
Total number of species	10
Species	**Percentage Cover**
Agrostis stolonifera	3
Epilobium palustre	1
Epilobium hirsutum	10
Holcus lanatus	1
Nasturtium officinale agg.	25
Helosciadium nodiflorum	5
Elytrigia repens	0.3
Ranunculus repens	0.5
Brachythecium rivulare	0.1
Fontinalis antipyretica	7

Item Recorded	Observation
Date (year/month/day	20200826
Altitude (m)	206
Longitude	-6.07071600
Latitude	53.37436000
X-coordinate	-605311.000
Y-coordinate	659397.000
Releve reference	AFHowthR_2
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	5.000 %
Total number of species	3
Species	**Percentage Cover**
Juncus effusus	70
Agrostis capillaris	25
Juncus bulbosus	0.1

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	193
Longitude	-6.07094500
Latitude	53.37545000
X-coordinate	-605307.000
Y-coordinate	659520.000
Releve reference	AFHowthR_3
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	15.000 %
Total number of species	5
Species	**Percentage Cover**
Molinia caerulea	55
Carex flacca	1
Juncus effusus	20
Salix cinerea subsp. *oleifolia*	0.1
Drepanocladus aduncus	5

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	198
Longitude	-6.07117000
Latitude	53.37390000
X-coordinate	-605349.000
Y-coordinate	659351.000
Releve reference	AFHowthR_4
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FS1
Cover of water	0.000 %
Total number of species	8
Species	**Percentage Cover**
Holcus lanatus	25
Rubus fruticosus agg.	0.5
Urtica dioica	0.1
Ranunculus repens	0.1
Arrhenatherum elatius	1
Juncus acutiflorus	5
Lathyrus pratensis	0.1
Phragmites australis	70

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	201
Longitude	-6.07101500
Latitude	53.37348000
X-coordinate	-605346.000
Y-coordinate	659303.000
Releve reference	AFHowthR_5
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.1000 %
Total number of species	9
Species	**Percentage Cover**
Agrostis stolonifera	40
Juncus conglomeratus	40
Ranunculus flammula	0.5
Holcus lanatus	5
Rubus fruticosus agg.	0.5
Salix cinerea subsp. oleifolia	0.1
Juncus acutiflorus	15
Lathyrus pratensis	0.1
Senecio jacobaea	0.3

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	161
Longitude	-6.05958000
Latitude	53.36901000
X-coordinate	-604671.000
Y-coordinate	658689.000
Releve reference	AFHowthR_6
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	15.000 %
Total number of species	4
Species	**Percentage Cover**
Nasturtium officinale agg.	80
Cratoneuron filicinum	1
Pellia endiviifolia	0.3
Callitriche species	1

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	169
Longitude	-6.06044200
Latitude	53.37060000
X-coordinate	-604700.000
Y-coordinate	658874.000
Releve reference	AFHowthR_7
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	0.000 %
Total number of species	10
Species	**Percentage Cover**
Agrostis stolonifera	1
Potentilla anserina	1
Epilobium hirsutum	5
Holcus lanatus	10
Rubus fruticosus agg.	3
Urtica dioica	1
Ranunculus repens	3
Equisetum telmateia	85
Pteridium aquilinum	1
Vicia sepium	0.1

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	149
Longitude	-6.05964900
Latitude	53.36801000
X-coordinate	-604693.000
Y-coordinate	658580.000
Releve reference	AFHowthR_8
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FL8
Cover of water	1.000 %
Total number of species	9
Species	**Percentage Cover**
Agrostis stolonifera	5
Ranunculus flammula	5
Typha latifolia	10
Nasturtium officinale agg.	1
Eleocharis palustris	7

Juncus acutiflorus	1
Lemna minor	30
Myosotis scorpioides	7
Nymphoides peltata	55

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	85
Longitude	-6.0809000
Latitude	53.36318000
X-coordinate	-606181.000
Y-coordinate	658273.000
Releve reference	AFHowthR_9
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FL8
Cover of water	50.000 %
Total number of species	6
Species	**Percentage Cover**
Epilobium parviflorum	0.1
Helosciadium nodiflorum	30
Pellia endiviifolia	1
Caltha palustris	20
Geranium robertianum	1
Conocephalum conicum	0.1

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	81

Longitude	-6.08116000
Latitude	53.36311000
X-coordinate	-606199.000
Y-coordinate	658268.000
Releve reference	AFHowthR_10
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	85.000 %
Total number of species	8
Species	**Percentage Cover**
Carex pendula	3
Acer pseudoplatanus	75
Hedera helix	5
Brachythecium rivulare	5
Pellia endiviifolia	0.3
Athyrium filix-femina	0.3
Sambucus nigra	15
Rhynchostegium riparioides	3

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	77
Longitude	-6.08133600
Latitude	53.3629000
X-coordinate	-606215.000
Y-coordinate	658246.000
Releve reference	AFHowthR_11
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	1.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	3
Epilobium hirsutum	3
Nasturtium officinale agg.	45
Helosciadium nodiflorum	40
Ranunculus repens	3
Juncus bufonius	1
Veronica beccabunga	10

Item Recorded	**Observation**

Date (year/month/day)	20200827
Altitude (m)	67
Longitude	-6.09583100
Latitude	53.37193000
X-coordinate	-607011.000
Y-coordinate	659395.000
Releve reference	AFHowthR_12
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	3
Species	**Percentage Cover**
Epilobium hirsutum	45
Elytrigia repens	55
Ranunculus repens	3

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	152
Longitude	-6.05991300
Latitude	53.37639000
X-coordinate	-604562.000
Y-coordinate	659507.000
Releve reference	AFHowthR_13
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	7
Species	**Percentage Cover**
Epilobium palustre	0.1
Holcus lanatus	10
Juncus effusus	80
Lythrum salicaria	15
Ranunculus repens	4
Vicia sepium	0.5
Filipendula ulmaria	0.5

Item Recorded	**Observation**

Date (year/month/day)	20200901
Altitude (m)	146
Longitude	-6.05964200
Latitude	53.37645000
X-coordinate	-6.04544.000
Y-coordinate	659510.000
Releve reference	AFHowthR_14
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FS2
Cover of water	5.000 %
Total number of species	7
Species	**Percentage Cover**
Epilobium palustre	0.1
Epilobium parviflorum	0.3
Ranunculus flammula	0.1
Typha latifolia	1
Juncus articulatus	60
Lythrum salicaria	20
Lemna minor	40

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	146
Longitude	-6.05959500
Latitude	53.37663000
X-coordinate	-604537.000
Y-coordinate	659529.000
Releve reference	AFHowthR_15
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.100 %
Total number of species	11
Species	**Percentage Cover**
Carex pendula	0.3
Epilobium hirsutum	5
Holcus lanatus	7
Rubus fruticosus agg.	1
Juncus articulatus	3
Juncus effusus	70
Mentha aquatica	10
Ranunculus repens	3
Betula pubescens	15

Silene flos-cuculi	1
Deschampsia cespitosa	3

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	149
Longitude	-6.05969400
Latitude	53.37659000
X-coordinate	-604545.000
Y-coordinate	659526.000
Releve reference	AFHowthR_16
Surveyor	AF
Releve area (m^2)	10
Fossitt Code	WN^ / GS4
Cover of water	0.100 %
Total number of species	17
Species	**Percentage Cover**
Carex pendula	1
Epilobium palustre	0.1
Epilobium parviflorum	1
Epilobium hirsutum	1
Equisetum fluviatile	0.5
Holcus lanatus	7
Rubus fruticosus agg.	35
Juncus articulatus	3
Juncus effusus	60
Lythrum salicaria	7
Mentha aquatica	0.1
Helosciadium nodiflorum	0.3
Filipendula ulmaria	3
Deschampsia cespitosa	0.5
Alnus glutinosa	50
Dryopteris dilatata	0.3
Stellaria alsine	0.1

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	155

Longitude	-6.06045600
Latitude	53.37529000
X-coordinate	-604618.000
Y-coordinate	659391.000
Releve reference	AFHowthR_17
Surveyor	AF
Releve area (m^2)	10
Fossitt Code	GS4
Cover of water	15.000 %
Total number of species	20
Species	**Percentage Cover**
Epilobium parviflorum	5
Equisetum arvense	7
Epilobium hirsutum	1
Holcus lanatus	1
Nasturtium officinale agg.	25
Juncus articulatus	25
Juncus effusus	30
Ranunculus repens	3
Senecio jacobaea	0.1
Cratoneuron filicinum	3
Pellia endiviifolia	5
Hypochaeris radicata	0.1
Isolepis setacea	0.1
Plantago lanceolata	0.1
Trifolium repens	0.3
Tussilago farfara	3
Brachythecium rutabulum	1
Didymodon species	0.3
Carex lepidocarpa	3
Bryum capillare	0.1

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	141
Longitude	-6.06229700

Latitude	53.37881000
X-coordinate	-604677.000
Y-coordinate	659799.000
Releve reference	AFHowthR_18
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	FW2
Cover of water	40.000 %
Total number of species	6
Species	**Percentage Cover**
Holcus lanatus	5
Urtica dioica	1
Helosciadium nodiflorum	50
Ranunculus repens	5
Rumex crispus	0.1
Filipendula ulmaria	3

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	77
Longitude	-6.06066400
Latitude	53.38585000
X-coordinate	-604444.000
Y-coordinate	660558.000

Releve reference	AFHowthR_19
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	10
Species	**Percentage Cover**
Agrostis stolonifera	20
Holcus lanatus	30
Eupatorium cannabinum	50
Urtica dioica	5
Ranunculus repens	35
Senecio jacobaea	1
Cirsium arvense	5
Poa trivialis	1
Rumex acetosa	1
Rumex obtusifolius	0.5

Item Recorded	**Observation**
Date (year/month/day)	20200901
Altitude (m)	76
Longitude	-6.06074500
Latitude	53.38581000
X-coordinate	-604450.000
Y-coordinate	660555.000
Releve reference	AFHowthR_20
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	5
Species	**Percentage Cover**
Agrostis stolonifera	40
Epilobium hirsutum	75
Holcus lanatus	5
Ranunculus repens	10
Rumex obtusifolius	1

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	142
Longitude	-6.05903300
Latitude	53.37661000

X-coordinate	-604501.000
Y-coordinate	659521.000
Releve reference	AFHowthR_21
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	8
Species	**Percentage Cover**
Agrostis stolonifera	10
Epilobium hirsutum	7
Holcus lanatus	10
Rubus fruticosus agg.	1
Calystegia sepium	5
Iris pseudacorus	15
Juncus effusus	60
Ranunculus repens	7

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	92
Longitude	-6.05063200
Latitude	53.38530000
X-coordinate	-603793.000
Y-coordinate	660391.000
Releve reference	AFHowthR_22
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	PF1 / GS4
Cover of water	0.000 %
Total number of species	11
Species	**Percentage Cover**
Epilobium palustre	0.5
Epilobium parviflorum	0.1
Ranunculus flammula	0.1
Samolus valerandi	0.3
Carex flacca	0.5
Juncus articulatus	25
Hedera helix	0.1
Chara vulgaris	15
Leontodon autumnalis	0.1
Ranunculus acris	0.1
Pohlia melanodon	0.1

Item Recorded	Observation
Date (year/month/day)	20200904
Altitude (m)	93
Longitude	-6.0507600
Latitude	53.38512000
X-coordinate	-603804.000
Y-coordinate	660372.000
Releve reference	AFHowthR_23
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	18
Species	**Percentage Cover**
Agrostis stolonifera	10
Equisetum arvense	35
Juncus inflexus	25
Ranunculus flammula	0.3
Hypericum tetrapterum	0.1
Rubus fruticosus agg.	0.1
Carex flacca	1
Eupatorium cannabinum	25
Cirsium palustre	1
Succisa pratensis	3
Ranunculus repens	0.3
Vicia sepium	0.3
Plantago lanceolata	0.3
Rumex acetosa	0.1
Ranunculus acris	3
Calluna vulgaris	0.3
Centaurea nigra	1
Plantago maritima	1

Item Recorded	Observation
Date (year/month/day)	20200904
Altitude (m)	94
Longitude	-6.05066200
Latitude	53.38509000
X-coordinate	-603798.000
Y-coordinate	660368.000

Releve reference	AFHowthR_24
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	PF1 / GS4
Cover of water	0.000 %
Total number of species	23
Species	**Percentage Cover**
Agrostis stolonifera	10
Equisetum arvense	3
Holcus lanatus	5
Hypericum tetrapterum	0.1
Samolus valerandi	0.1
Carex flacca	1
Juncus articulatus	7
Eupatorium cannabinum	5
Cirsium palustre	1
Equisetum palustre	1
Succisa pratensis	1
Dactylorhiza species	0.1
Juncus bulbosus	0.1
Festuca rubra agg.	15
Plantago lanceolata	3
Plantago maritima	15
Linum catharticum	0.1
Prunella vulgaris	0.1
Calliergonella cuspidata	3
Bryum species	0.1
Taraxacum agg.	0.1
Viola species	0.1
Hypnum lacunosum	1

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	95
Longitude	-6.05014800
Latitude	53.38520000
X-coordinate	-603762.000
Y-coordinate	660375.000
Releve reference	AFHowthR_25

Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	8
Species	**Percentage Cover**
Agrostis stolonifera	30
Ranunculus flammula	3
Hypericum tetrapterum	3
Senecio aquaticus	7
Juncus articulatus	55
Succisa pratensis	7
Festuca rubra agg.	3
Plantago lanceolata	5

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	118
Longitude	-6.04771500
Latitude	53.38400000
X-coordinate	-603623.000
Y-coordinate	660217.000
Releve reference	AFHowthR_26
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	6
Species	**Percentage Cover**
Potentilla anserina	35
Holcus lanatus	50
Juncus articulatus	0.5
Plantago lanceolata	0.5
Trifolium repens	10
Lolium perenne	1

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	125
Longitude	-6.04770300
Latitude	53.38400000
X-coordinate	-603622.000
Y-coordinate	660217.000

Releve reference	AFHowthR_27
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	8
Species	**Percentage Cover**
Potentilla anserina	7
Epilobium hirsutum	15
Holcus lanatus	50
Rubus fruticosus agg.	1
Ranunculus repens	20
Cirsium arvense	3
Lolium perenne	0.1
Pulicaria dysenterica	7

Item Recorded	**Observation**
Date (year/month/day)	20200904
Altitude (m)	121
Longitude	-6.04641700
Latitude	53.38305000
X-coordinate	-603554.000
Y-coordinate	660098.00
Releve reference	AFHowthR_28
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	30.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	15
Epilobium hirsutum	30
Rubus fruticosus agg.	1
Ranunculus repens	3
Arrhenatherum elatius	15
Pteridium aquilinum	1
Dactylis glomerata	10

Item Recorded	**Observation**
Date (year/month/day)	20200914
Altitude (m)	98
Longitude	-6.08664700
Latitude	53.36801000

X-coordinate	-606474.000
Y-coordinate	658866.000
Releve reference	AFHowthR_29
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	25
Potentilla anserina	20
Holcus lanatus	7
Juncus effusus	60
Arrhenatherum elatius	15
Vicia sepium	3
Rumex acetosa	0.1

Item Recorded	**Observation**
Date (year/month/day)	20200914
Altitude (m)	151
Longitude	-6.07845200
Latitude	53.36829000
X-coordinate	-605929.000
Y-coordinate	658810.000
Releve reference	AFHowthR_30
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	13
Species	**Percentage Cover**
Agrostis stolonifera	35
Epilobium hirsutum	7
Holcus lanatus	15
Rubus fruticosus agg.	3
Juncus effusus	45
Mentha aquatica	1
Ranunculus repens	5
Pteridium aquilinum	0.3
Cirsium arvense	3
Rumex obtusifolius	0.5
Prunus spinosa	1
Stellaria graminea	0.1
Vicia cracca	3

Item Recorded	Observation
Date (year/month/day)	20200914
Altitude (m)	133
Longitude	-6.0784470
Latitude	53.36831000
X-coordinate	-605928.000
Y-coordinate	658812.000
Releve reference	AFHowthR_31
Surveyor	AF
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	0.000 %
Total number of species	12
Species	**Percentage Cover**
Agrostis stolonifera	30
Epilobium hirsutum	15
Holcus lanatus	30
Rubus fruticosus agg.	3
Urtica dioica	1
Juncus effusus	5
Ranunculus repens	5
Pteridium aquilinum	3
Filipendula ulmaria	30
Cirsium arvense	1
Vicia cracca	0.3
Stellaria holostea	0.1

Item Recorded	Observation
Date (year/month/day)	20200826
Altitude (m)	154
Longitude	-6.07507200
Latitude	53.37728000
X-coordinate	-605546.000
Y-coordinate	659765.000

Releve reference	CCHpwth_R2
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	10.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	1
Anthoxanthum odoratum	0.5
Galium aparine	0.05
Holcus lanatus	25
Juncus acutiflorus	80
Rumex acetosa	0.5
Rubus fruticosus agg.	1

Item Recorded	**Observation**
Date (year/month/day)	20200826
Altitude (m)	161
Longitude	-6.07518700
Latitude	53.37732000
X-coordinate	-605553.000
Y-coordinate	659772.000
Releve reference	CCHowth_R3
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	10.000 %
Total number of species	6
Species	**Percentage Cover**
Agrostis stolonifera	30
Juncus effusus	25
Holcus lanatus	30
Dactylis glomerata	15
Potentilla palustris	0.05
Rubus fruticosus agg.	1

Item Recorded	**Observation**
Date (year/month/day)	20200826
Altitude (m)	155
Longitude	-6.07525500
Latitude	53.37733000
X-coordinate	-605558.000
Y-coordinate	659773.000

Releve reference	CCHowth_R4
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	GS4
Cover of water	10.000 %
Total number of species	6
Species	**Percentage Cover**
Agrostis stolonifera	35
Juncus effusus	1
Holcus lanatus	30
Juncus acutiflorus	10
Potentilla palustris	25
Rubus fruticosus agg.	5

Item Recorded	**Observation**
Date (year/month/day)	20200826
Altitude (m)	66.3
Longitude	-6.09154700
Latitude	53.38442000
X-coordinate	-606506.000
Y-coordinate	660728.000
Releve reference	CCHowth_R5
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	GS4 / FS1
Cover of water	10.000 %
Total number of species	6
Species	**Percentage Cover**
Cardamine pratensis	0.05
Epilobium hirsutum	0.05
Juncus articulatus	85
Ranunculus flammula	10
Typha latifolia	5
Brachythecium species	0.3

Item Recorded	**Observation**
Date (year/month/day)	20200826
Altitude (m)	72.8
Longitude	-6.09124300
Latitude	53.38453000
X-coordinate	-606484.000

Y-coordinate	660736.000
Releve reference	CCHowth_R6
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	GS4 / FS1
Cover of water	10.000 %
Total number of species	11
Species	**Percentage Cover**
Agrostis stolonifera	35
Holcus lanatus	35
Cardamine pratensis	0.05
Epilobium hirsutum	15
Juncus articulatus	15
Typha latifolia	0.05
Epipactis palustris	3
Fraxinus excelsior	1
Pulicaria dysenterica	1
Calliergonella cuspidata	5
Eleocharis species	0.05

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	74.8
Longitude	-6.07747200
Latitude	53.38655000
X-coordinate	-605540.000
Y-coordinate	660814.000
Releve reference	CCHowth_R7
Surveyor	CC

Releve area (m^2)	2
Fossitt Code	FS2
Cover of water	10.000 %
Total number of species	4
Species	**Percentage Cover**
Epilobium hirsutum	60
Typha latifolia	10
Berula erecta	1
Nasturtium officinale agg.	35

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	76.4
Longitude	-6.07760900
Latitude	53.38679000
X-coordinate	-605545.000
Y-coordinate	660841.000
Releve reference	CCHowth_R8
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	FS1
Cover of water	10.000 %
Total number of species	4
Species	**Percentage Cover**
Rubus fruticosus agg.	1
Typha latifolia	75
Angelica sylvestris	0.05
Filipendula ulmaria	3

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	58.8
Longitude	-6.11038600
Latitude	53.39091000
X-coordinate	-607633.000
Y-coordinate	661644.000
Releve reference	CCHowth_R9
Surveyor	CC
Releve area (m^2)	2

Fossitt Code	CM1 / CM2
Cover of water	10.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	8
Arrhenatherum elatius	5
Carex arenaria	1
Puccinellia maritima	5
Trifolium pratense	1
Atriplex species	5
Festuca rubra agg.	85

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	57.9
Longitude	-6.11029400
Latitude	53.39087000
X-coordinate	-607627.000
Y-coordinate	661639.000
Releve reference	CCHowth_R10
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	FS1 / CM2
Cover of water	10.000 %
Total number of species	7
Species	**Percentage Cover**
Agrostis stolonifera	15
Typha latifolia	3
Carex arenaria	75
Cirsium arvense	5
Juncus gerardii	15
Atriplex species	0.3
Festuca rubra agg.	25

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	58.8
Longitude	-6.10881700
Latitude	53.39079000
X-coordinate	-607532.000
Y-coordinate	661614.000
Releve reference	CCHowth_R11
Surveyor	CC

Releve area (m^2)	2
Fossitt Code	FS1 / FS2
Cover of water	10.000 %
Total number of species	10
Species	**Percentage Cover**
Epilobium hirsutum	40
Typha latifolia	3
Festuca rubra agg.	15
Arrhenatherum elatius	40
Calystegia sepium	3
Cirsium vulgare	0.05
Elytrigia repens	20
Iris pseudacorus	15
Schoenoplectus lacustris	10
Carex species	0.1

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	63.0
Longitude	-6.10722100
Latitude	53.39111000
X-coordinate	-607421.000
Y-coordinate	661633.000
Releve reference	CCHowth_R12
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	FS1

Cover of water	10.000 %
Total number of species	9
Species	**Percentage Cover**
Epilobium hirsutum	5
Typha latifolia	1
Pulicaria dysenterica	10
Schoenoplectus lacustris	5
Bolboschoenus maritimus	35
Equisetum fluviatile	1
Juncus subnodulosus	1
Potamogeton natans	1
Chara species	0.3

Item Recorded	**Observation**
Date (year/month/day)	20200827
Altitude (m)	62.3
Longitude	-6.10928600
Latitude	53.39226000
X-coordinate	-607536.000
Y-coordinate	661781.000
Releve reference	CCHowth_R13
Surveyor	CC
Releve area (m^2)	2
Fossitt Code	FS1
Cover of water	10.000 %
Total number of species	4
Species	**Percentage Cover**
Agrostis stolonifera	15
Typha latifolia	30
Schoenoplectus lacustris	15
Bolboschoenus maritimus	15

Appendix III

Envirologic (2020): Hydrological Assessment of Howth Wetlands – Report

ENVIROLOGIC

HYDROGEOLOGICAL | HYDROLOGICAL CONSULTING

Hydrological Assessment of Howth Wetlands

Location:	Howth, Co. Dublin
Prepared for:	Fingal County Council
Prepared by:	Colin O'Reilly PhD (Hydrology)
Date:	28/01/21
Reference no.	1779 v2

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Introduction

The following hydrological assessment has been prepared by Colin O'Reilly PhD (Hydrology) on behalf of Fingal County Council. The report is intended to accompany an ecological assessment prepared by Alexis Fitzgerald of Scott Cawley.

Study Area

The study area is Howth Head which covers the peninsula of Howth. For the purposes of this assessment Howth Head is considered to be all lands east of a line that runs from the western side of Sutton Golf Club through Sutton crossroads and along the western side of the Marine Hotel into Dublin Bay. The study area is approximately 11.5 km^2 (1,150 hectares).

Background

Historical maps and survey records from the 19th century show that wetlands such as ponds, streams and shallow wells used to be prevalent across Howth and that many of these habitats supported unique plant communities and in some scenarios rare plant species. Recent studies have revealed an alarming reduction in these features, with the cause for their disappearance not fully understood.

Wetlands are not a qualifying feature of Howth Head SAC but they do constitute important habitat features within the dry heath habitat, for which the site is designated. The Howth Special Area Amenity Order (SAAO) has the objective of protecting and sustaining nature including wetlands and the SAAO Operational Plan 2015-2020 includes a specific objective for wetlands:

- *Action 1.1 - Map former and existing waterbodies (wetlands, springs, streams etc) and make comparison with historical data and maps.*

Aim

The aim of the first phase of this study is to locate all existing wetlands in Howth, characterise the hydrological regime and identify associated flora species. Findings will be compared with historical records to determine where and what changes to vegetation communities have occurred. A second phase may focus on more detailed assessments and proposals for wetland restoration.

Methodology

A programme of works was agreed with ecological consultants Scott Cawley and findings reported to Fingal County Council on a phased basis.

<u>Mapping of Recorded Wetland Features</u>

Envirologic made reference to current and historical maps and third party literature sources to identify all wells, springs, waterbodies and watercourses in Howth. These records were transposed onto current aerial imagery using MapInfo and QGIS mapping software and georeferenced to Irish Transverse Mercator (ITM) coordinate system. Approximately forty features were identified in the mapping and literature review phase.

Groundtruthing

The identified wetland features were groundtruthed to assess whether they still existed. Where present a desk and field-based assessment of their current status in terms of ecology and hydrology was carried out. For wetland features no longer present the likely pressures associated with their disappearance was surmised.

Field Surveying

Following discussion with the consultant ecologist a shortlist of sites was drawn up, with these considered to be most valuable (or potentially most valuable) in terms of supporting important plant communities.

Guideline criteria to be recorded at shortlisted wetland features included: (i) extents and depth of wetted feature, (ii) ground and surface water elevation, (iii) inferred seasonal min./max. water level, (iv) inflow/outflow points and elevations, (v) flowrate (vi) artificial drainage features and elevations, (vii) ground and aerial photograph (where feasible), (viii) evidence of pressures to quality (e.g. erosion, road runoff), (ix) visual clarity of water, (x) unstable hydrochemistry, (xi) any other relevant observations. Additional features to be included at linear watercourses included (i) cross-sectional dimensions, (ii) gradient, (iii) bed substrate, (iv) flowrate, (v) proximity of structures.

Reporting of Survey Findings

The report is intended to clearly communicate all findings from field surveys. Where relevant additional analysis will be performed to include geological, hydrogeological and hydrogeological controls, catchments, drainage patterns, pressures in terms of flow and quality.

Site specific measures for protection and/or remediation will be recommended to inform the next phase of works.

Site Description

Landscape

Howth can be considered broadly circular in shape, with a diameter of between 3 and 4 km (Figure 1). Up until around 3,500 years ago the peninsula was an island though it is now connected to the mainland via a raised sand and gravel beach protruding westwards from the northwest corner at Sutton.

The highest region of Howth is located just south of the centre point where a number of peaks exist in close proximity, these being referred to as follows:

(i) Ben of Howth (Black Linn) (171 mOD) – notable by the presence of a telecommunications mast;

(ii) Shielmartin (163 mOD) – surrounded to the west, north and east by Howth Golf Club while the southern slope falls to the south coast;

(iii) Carrickbrack – east of Howth Golf Club and south of Ben of Howth;

(iv) Muck Rock - raised bedrock plateau southwest of Deer Park Hotel which has a steep, north-facing escarpment.

(v) Dun Hill – peak short distance south of Muck Rock, adjacent to the northern boundary of Howth Golf Club.

From this cluster of peaks raised ground extends east towards an inland peak referred to as the summit (close to the Summit Inn) and progress onto to the coastline. Steep cliffs define the eastern coastline between Dungriffin Promontory at the southern end, upon which Baily lighthouse is sited, to the northeastern tip, known as the nose. This area of elevated land along the east coast is known as East Mountain. In the northeastern corner of Howth the steep cliffs continue around the eastern half of the north coast to Balscadden Beach in an area known as Kilrock. Exposed bedrock abruptly gives way to a sand and gravel moraine in the village which forms Tower Hill, site of a Martello Tower.

West of Howth village topography flattens out towards shallow sand dunes to the rear of Burrow Beach. From this low-lying area lands rise much more gradually through Howth Castle towards Deer Park Hotel. Similarly moderate gradients connect Deer Park Hotel to the western coastline, between which Deer Park Golf Course continues. The southern half of the west coast and the south coast is characterised by shallow cliffs and a rugged foreshore (Figure 2).

Bedrock Geology

Geology has formed the landscape of Howth. There are two types of bedrock in Howth which are separated by a structural fault that runs from southwest, close to the entrance of Redrock, to northeast at Balscadden Beach. It is evident inland along the escarpment that runs along the northwestern boundary of Howth Golf Club and to the rear of Deer Park Hotel. A secondary faultline runs to the south and parallel and can be observed as a narrow woodland valley running between Muck Rock and the escarpment.

Bedrock on higher ground east of the major fault is composed of metasediments created in the Cambrian Period. These rocks are categorised as the second oldest rock type in Ireland (500 million years) and contain the earliest evidence of life. They are sedimentary in nature so were laid down in horizontal bedded sequences, however these have largely been shattered and contorted by tectonic movements which gives a chaotic appearance and variation in size from pebbles to blocks of massive structure.

Within this Bray Group several distinguishable bedrock formations are mapped, these being illustrated in Figure 3 (compiled using bedrock data obtained from GSI database at www.gsi.ie) as:

(i) Drumleck Formation – quartzite blocks and pebbles in a mudstone matrix. The quartzite is made distinct from its purer sand content. It tends to be mostly visible on the highest areas as it is more resistant to erosion. Clearly exposed on Muck Rock and Dun Hill, continuing to the west coast and south into Censure.

(ii) Elsinore Formation – mixture of greywacke, siltstone, mudstone, sandstone and quartzite, often massive in structure. Clearly exposed in the central area around Ben of Howth and Greenhollows and also at Kilrock quarry and nose of Howth. These rocks are often rusty brown in colour and termed locally as 'Howth stone'.

(iii) Pipers Gut Formation - Greywacke, a sedimentary rock composed of muddy sand. Mapped at surface in the area between Thornamby Woods and due east to the coast.

(iv) Hippy Hole Formation - . Confined to the Whitewater Brook valley and a narrow margin along Carrickbrack Road between farmland and Jameson Beach.

Much later during the Lower Carboniferous period limestones were formed from sedimentation when the northwest area of Howth (and much of the greater Dublin area) was covered by warm and shallow topical seas supporting corals, crinoids and brachiopods. Across much of Sutton and Deer Park Golf Course these are Waulsortian limestones which are pure (clean) and massive in structure with bedding planes absent. The more muddy limestones belonging to the Ballysteen Formation are mapped closer to Howth village.

Quaternary Deposits

Howth was covered in an ice sheet during the last Ice Age. During the glacial retreat approximately 14,000 years ago the ice and meltwaters scoured various small valleys which terminate at the coast. Most, but not all, of these valleys transmit the main streams that flow radially from the centre.

The lower ground in Howth is overlain by superficial calcareous glacial deposits of variable thickness comprised of a boulder clay intermixed with gravel of Irish Sea origin. The southern extents of limestone till extend to cover Red Rock to the south and Nashville Road to the east. This till tends to be heavy and of low to moderate permeability and is visible at the western end of Claremont Strand and on Burrow Beach. Limestone gravels have been mapped around Howth Castle and across almost all of Howth village with smaller pockets at Howth allotments and Balscadden car park. Such gravelly sand layers are visible from Balcadden Road on the eastern side of the sand and gravel moraine at Tower Hill.

The hard Cambrian rocks on raised ground east of the structural fault aren't prone to significant weathering so subsoils are almost entirely absent across large areas of raised ground (Figure 4, compiled using subsoil data obtained from Teagasc database at www.gsi.ie)). Where present they are mapped as a till derived from quartzites. This unit tends to be sandier in texture which gives it improved drainage characteristics. It can be clearly observed on the eastern cliff faces as having thickness up to 5 m.

Howth peninsula is connected to the mainland by a post-glacial tombolo, consisting of raised marine sands and gravels resting on limestone bedrock.

Lacustrine deposits are mapped in the depression occupied by the pond on Howth Golf Club.

Soils

Figure 5 (compiled using soil data obtained from Teagasc database at www.gsi.ie) shows that soil covering much of the Cambrian rock in Howth is thin, acidic and has a very low nutrient status. It also has poor moisture retention capability. Soils derived from these rocks are a simple blend of fine fragments of weathered bedrock sheared from the bedrock and peaty podzols, derived from the accumulation of organic matter arising from the cyclical degradation of vegetation at the surface. Organic matter that gets washed into topographical depressions and valley floors means that soil depth is greater in these localised areas.

Soils on the lower limestones tend to be more mineralised in nature given the higher clay content in the glacial deposits. These minerals include calcium carbonate which gives these soils an alkaline signature. The soils developed over the limestone areas are relatively fertile grey brown podzolics. These areas are covered in almost equal proportion by the residential housing of Sutton and Deer Park golf course.

Hydrogeology

Perhaps not surprisingly the Cambrian rocks have been classified by the GSI as a poor aquifer which is generally unproductive except for local zones. Poorly productive aquifers are characterised by very low permeabilities and transmissivities and are therefore low yielding. Consequently, groundwater movement within this bedrock is relatively low and is often restricted to shallow flow paths near the surface or along fracture zones. Well and spring yields within this aquifer class are typically low. Given the lack of protective overburden the Cambrian rocks in Howth are considered to be vulnerable to contamination (E/X).

The massive unbedded limestones can return slightly higher yields and as such are regarded as a locally important aquifer, being moderately productive only in local zones. The general lack of bedding and jointing in Waulsortian bedrock means groundwater flows within are limited to fracture zones. Groundwater vulnerability classification across the limestone areas is typically High (H).

There is little detail regarding groundwater abstractions on Howth. The GSI database contains records of shallow wells at St Fintan's (holy well) and Balsaggart. These wells are mapped close to the primary fault line and the presence of broken rocks (breccia) along the faultline caused by tectonic movement may be a primary groundwater flow path. At a local level there are reportedly domestic wells with moderate yields on Burrow Road and close to the southern coastline.

Hydrology

The EPA database of watercourses in Ireland shows five first order streams on Howth peninsula, progressing clockwise from Sutton. Additional watercourses illustrated in Rivers of Dublin (Sweeney, 2017) are also listed below and included in Figure 6.

(i) Bloody Stream – rises near Greenhollows cottage, flows north through Howth Demesne, outfalls at Claremont Beach;

(ii) Offington Stream - flows north along the western side of the path which was formerly the tram line, just west of Balkill Park, Grace O'Malley and Evora Park residential streets. The outfall point is reportedly to the middle harbour. This is a dry channel for the majority of the year.

(iii) Bogeen Stream (also known as Gray's Stream & Balscadden Stream) - rises in Thormanby Woods, flows north along Gray's Lane and culverted beneath Main Street before outfalling to Howth harbour, east of Howth Yacht Club;

(iv) Coulcour Brook – flows north along Cowbooter Lane, outfalls to Balscadden Bay;

(v) Whitewater Brook – rises in a minor valley near Ben of Howth, flows southeast passing close to The Summit and outfalls to a small beach north of Baily lighthouse;

(vi) Balsaggart Stream – rises in the eastern part of Howth Golf Club south of Dun Hill, flows south through a working farm and an area known as 'The Cliffs';

(vii) Carrickbrack Stream - rises between Dun Hill and Shielmartin and flows west, draining the western half of Howth Golf Club and the southwest area of Deerpark. The watercourse is culverted between Carrickbrack Road and has its outfall along the coast at Strand Road.

(viii) Santa Sabina Stream - The Santa Sabina Stream is almost entirely culverted and flows west, draining a relatively small area of Deerpark which collects in a wetland area. The wetland consists of two ponds which outfall separately into a stormwater network through Offington residential estate, outfall to the coast opposite Santa Sabina Dominican College.

(ix) Howth Castle Streams - a series of small, mostly culverted drainage channels that flow to the rear of Howth Castle and outfall on Claremont Beach.

Catchment boundaries have been delineated by Envirologic using OS 1:50,000 Discovery Maps. All catchments contain areas drained by stormwater networks and in these areas the catchment boundaries are estimated. These man-made subsurface drainage networks occur predominantly beneath residential areas and local golf courses.

Catchment sizes are limited to less than 1 km^2. Given the low permeability of underlying bedrock and the steep hydraulic gradients most of the streams exhibit quite a flashy hydrograph in that they display a rapid flow response following rainfall and tend to have very low flow or dry up completely during summer months.

Groundtruthing

Groundtruthing of hydrological features was carried out by Colin O'Reilly of Envirologic between 19th August and 1st October 2020. Approximately 40 features were identified from historical mapping, literature review and through discussions with local residents during the groundtruthing exercise itself. Primary pressures to flow regime were mostly attributed to drainage (both arterial and stormwater networks) and construction of residential properties. Impoundments, changes to hydromorhpology and groundwater abstractions are considered to be secondary pressures. Some features were mapped within private residences; where homeowners were present these were groundtruthed, otherwise these were generally not revisited due to time constraints and likely difficulties in future work.

Upon completion of the groundtruthing exercise the list of features have been grouped under the surface water catchments within which they were identified.

Field Sheets

Items of interest, ground levels and water levels were surveyed by Envirologic using Trimble RTK R4 VRS with vertical and horizontal accuracy of 0.03 m. Easting and northing coordinates are relative to ITM, and elevations are tied to Malin Head datum.

Unstable hydrochemistry was recorded by Envirologic at some sites using an InSitu Aquatroll. pH and DO parameters calibration was not satisfactory and these values should be re-tested following successful calibration before attempting to analyse any trends.

The field sheets present opinion of Envirologic regarding the primary pressures affecting each site and provide recommendations which may improve or restore flow regime and/or quality.

River Habitat Survey

In consultation with Fingal County Council Envirologic have made use of the guidance document: *River Habitat Quality - the physical character of rivers and streams in the UK and Isle of Man* (Raven et al., 1998) to derive a naturalness index for watercourses in Howth. Using various criteria to describe stream hydromorphology the guidance outlines how the following useful indices can be derived:

(i) River Habitat Survey (RHS) - a scheme developed for assessing the physical character and quality of river habitats;

(ii) Habitat Modification Score (HMS) - modification to the channel expressed as a score based upon type and extent of artificial features;

(iii) Habitat Quality Assessment score (HQA) - habitat quality of a site expressed as a score based upon extent and variety of natural features recorded.

The criteria for calculating HMS are displayed in Table 1, with the HMS being the sum of all identified feature scores. The assessment criteria were applied on 500 m channel segments or where a significant change in channel type occurred. Whilst the guidance has proven extremely useful in providing a quantitative basis for comparing naturalness of watercourses in Howth some limitations to the approach must be acknowledged:

- Colin O'Reilly is not an accredited RHS field surveyor;
- The index was developed using 10 km^2 grid squares in Scotland and Northern Ireland. Within these grid squares the guidance document shows that only 1-3 sites fitted the qualifying criteria.
- Small catchment sizes and regime whereby flow rates in almost all of the watercourses in Howth approach zero during a dry summer can lead to an overemphasis of the impact of culverts.
- Biological factors such as the presence of non-native plant species are not included in the scoring system. These are catered for in the RHS and and HQA indices.

Table 1 - Habitat Modification Score (HMS) rules

Modifications	Score per Spot Check
Reinforcement to banks	2
Reinforcement to bed	2
Resectioned bank or bed	1
Two-stage bank modification	1
Embankment	1
Culvert	8
Dam, weir, ford	2
Bank poached by livestock	0-2
Artificial bed material	1
Weed-cutting	1
Bank-mowing	1
Footbridge	0
Roadbridge	1
Partial flow control	1
Extensive flow control	2
Partial realignment	5
Extensive realignment	10

The total score was used to categorise each discrete watercourse segment (Table 2) and these have been colour-coded to provide a graphical representation of stream naturalness across Howth in Figure 8. Given the propensity of long culverted sections in the area these have been given their own separate category, though they are considered to correlate with 'severely modified'. No 'pristine' streams, i.e. having no artificial modification, exist on Howth. Four sections of stream channel are classified as semi-natural, with these occurring primarily in the higher areas where no development works have taken place.

Table 2 - HMS categories for describing the stream naturalness

HMS Score	Descriptive category of channel
0	Pristine
0-2	Semi-natural
3-8	Predominantly unmodified
9-20	Obviously modified
21-44	Significantly modified
45+	Severely modified

The outcome of the HMS may inform development of a future catchment management plan for Howth watercourses and restoration of wetland features. Water quality data, which may be acquired in a follow-up phase to this study, can be integrated into the HMS to inform a HQA. With regard to water quality, the HQA categories assigned are as follows: Excellent, Good, Fair and Bad.

Further Works

A number of recommendations have been outlined in the field sheets for each site with a view to restoring and repairing existing wetlands. These measures are targeted at improving flow regime, water quality, reducing the HMS score, and ultimately improving habitat diversity.

In addition to those items a water quality monitoring programme is being considered to assist with the aim of identifying impacts from diffuse (e.g. fertiliser application, grazing animals) and point (e.g. faulty septic tanks) sources of contamination.

Water Quality Sampling

Envirologic have illustrated a total of 31 prospective water quality monitoring locations in Figure 9. These are generally at the upgradient and downgradient ends of the catchment, with interim sampling points at appropriate and accessible sites.

Proposed parameters for analysis are show below in Table 3. It is preferable to sample four times in a commencement year in order to capture any seasonality effect. The first sample round should serve as a screening exercise and will therefore contain all parameters listed in Table 3; quarterly or bi-annual sampling thereafter would not need to include hydrocarbons or pesticides, unless previously detected.

Table 3 - Proposed parameters to be included in water quality monitoring programme

Parameter Group	Parameter	Parameter Group	Parameter	Parameter Group	Parameter
Unstable (field)	Conductivity	Metals (filtered)	Iron	Major ions	Potassium
	pH		Manganese		Sodium
	Dissolved oxygen		Arsenic		Sulphate
	Temperature		Chromium		Chloride
	Redox		Copper	Microbiological	Faecal coliforms
			Lead		Total coliforms
Nutrients	Orthophosphate		Nickel		
	Total phosphorus		Zinc	Physico-chemical	Suspended solids
	Nitrates		Lead		Total organic carbon
	Nitrites				
	Ammoniacal N			Hydrocarbons	EPH (C8-C40)
				Pesticides	

Wetland Creation Feasibility

Figure 9 highlights areas which have been identified as having the potential for new wetland creation. Fingal County Council view new wetland cells as being beneficial not alone for habitat creation but to serve as firebreaks and firefighting water supplies. The wetlands may be variable in areal footprint and in depth depending on spatial constraints and depth to bedrock, respectively. The wetlands can then be arranged in sequence either in-line or off-line relative to existing open channel routings. Connecting sections may be re-profiled to create variations in hydraulic gradient and allow for a range of flow velocities, with higher more turbulent flows through steeper riffles and lower more laminar flow through shallower pools. This can be achieved by introducing bends to connecting channels.

Works within prospective areas would involve the following:

- Mechanical clearance of vegetation to reveal ground surface;
- Combination of drone survey and RTK surveying to develop a digital elevation model (DEM) for the areas in question;
- Assess DEM data to identify enclosed topographical depressions, or areas where minor embankment installation would create enclosed topographical depressions;
- Conduct soil probing using a hand auger to establish depth to bedrock within areas of interest. Trial pitting using a mechanical excavator may be required to facilitate probing.
- Estimate volumes of material to be removed for wetland development, volume of wetland created and depth of ponds, inlet and outlet elevations.

Areas suited to a pile scheme to test the above strategy include (i) the area between Greenhollows cottage and Bog of Frogs, and (ii) Nose of Howth - eastern stream.

Small diameter piezometers can be installed in any hand angered core holes to facilitate water depth monitoring either on an intermittent basis (manual) or continuous (automated using an appropriate water level datalogger).

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Figures

Legend:

Study Area

Fig. 1:	Site Location Map
Date:	November 2020
No.:	1779
Author:	C. O'Reilly
Scale:	1 : 22 500
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co. Dublin

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Legend:

Study Area

0 750

metres

Fig. 2:	Aerial View
Date:	November 2020
No.:	1779
Author:	C. O'Reilly
Scale:	1 : 22 500
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co. Dublin

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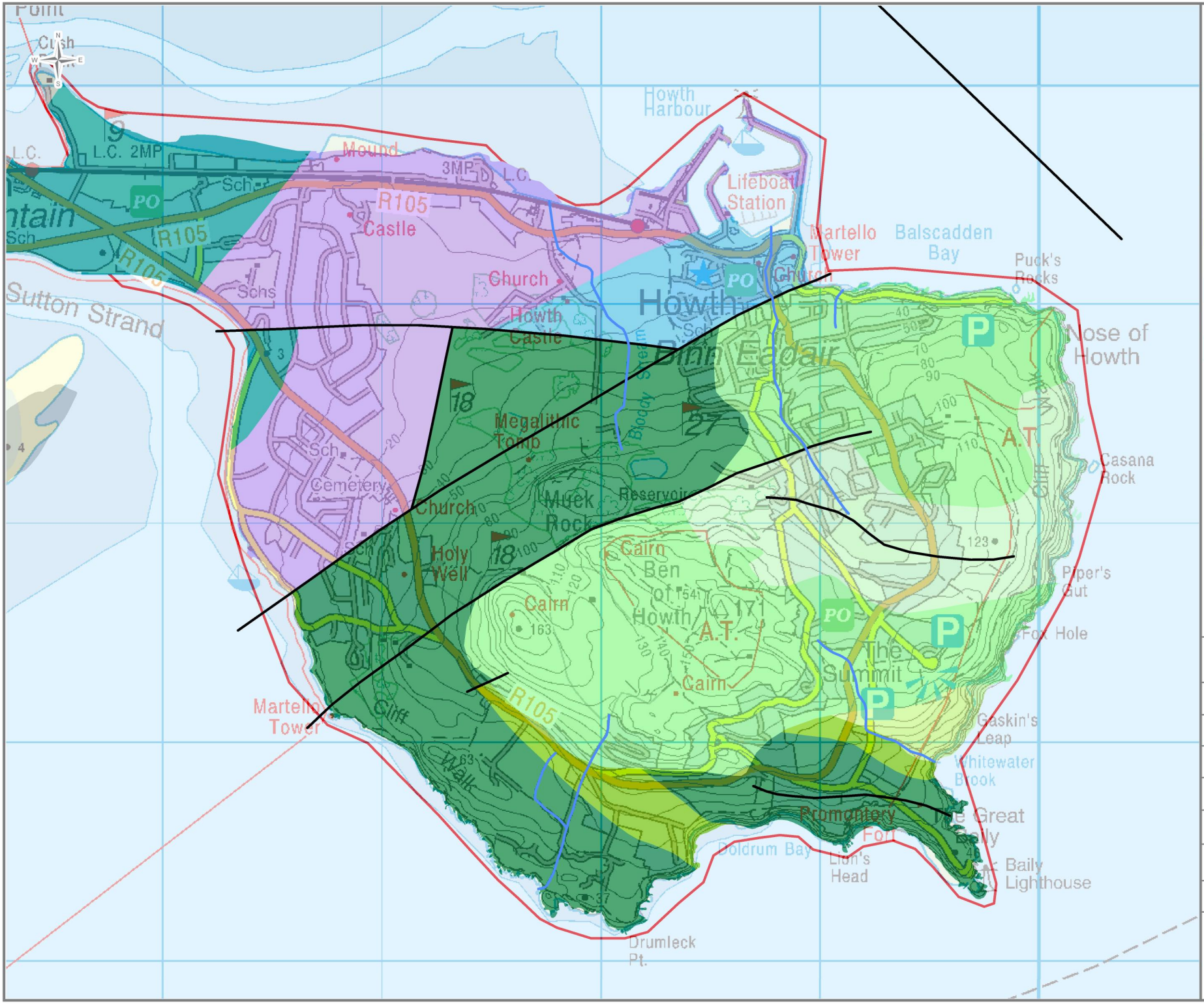

Legend:

- Study Area
- EPA Rivers & Streams
- Drumleck Formation
- Elsinore Formation
- Gaskins Leap Formation
- Hippy Hole Formation
- Pipers Gut Formation
- Ballysteen Formation
- Waulsortian Limestones
- Tober Colleen Formation
- Lucan Formation
- Structural Faulting

0 750

metres

Fig. 3:	Bedrock & Structural Geology
Date:	November 2020
No.:	1779
Author:	C. O'Reilly
Scale:	1 : 22 500
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co. Dublin

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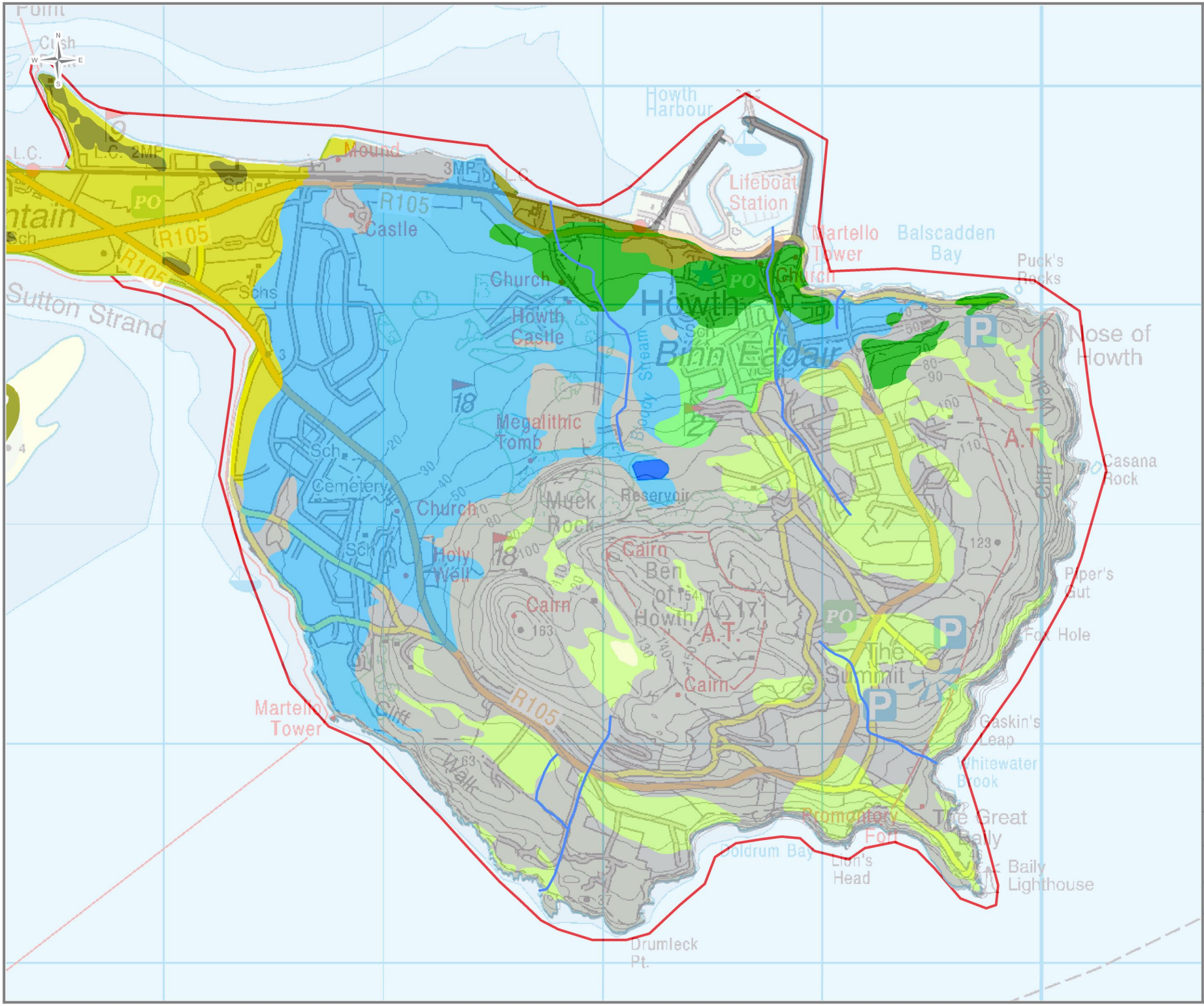

Fig. 4:	Quaternary Deposits
Date:	November 2020
No.:	1779
Author:	C. O'Reilly
Scale:	1 : 22 500
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co. Dublin

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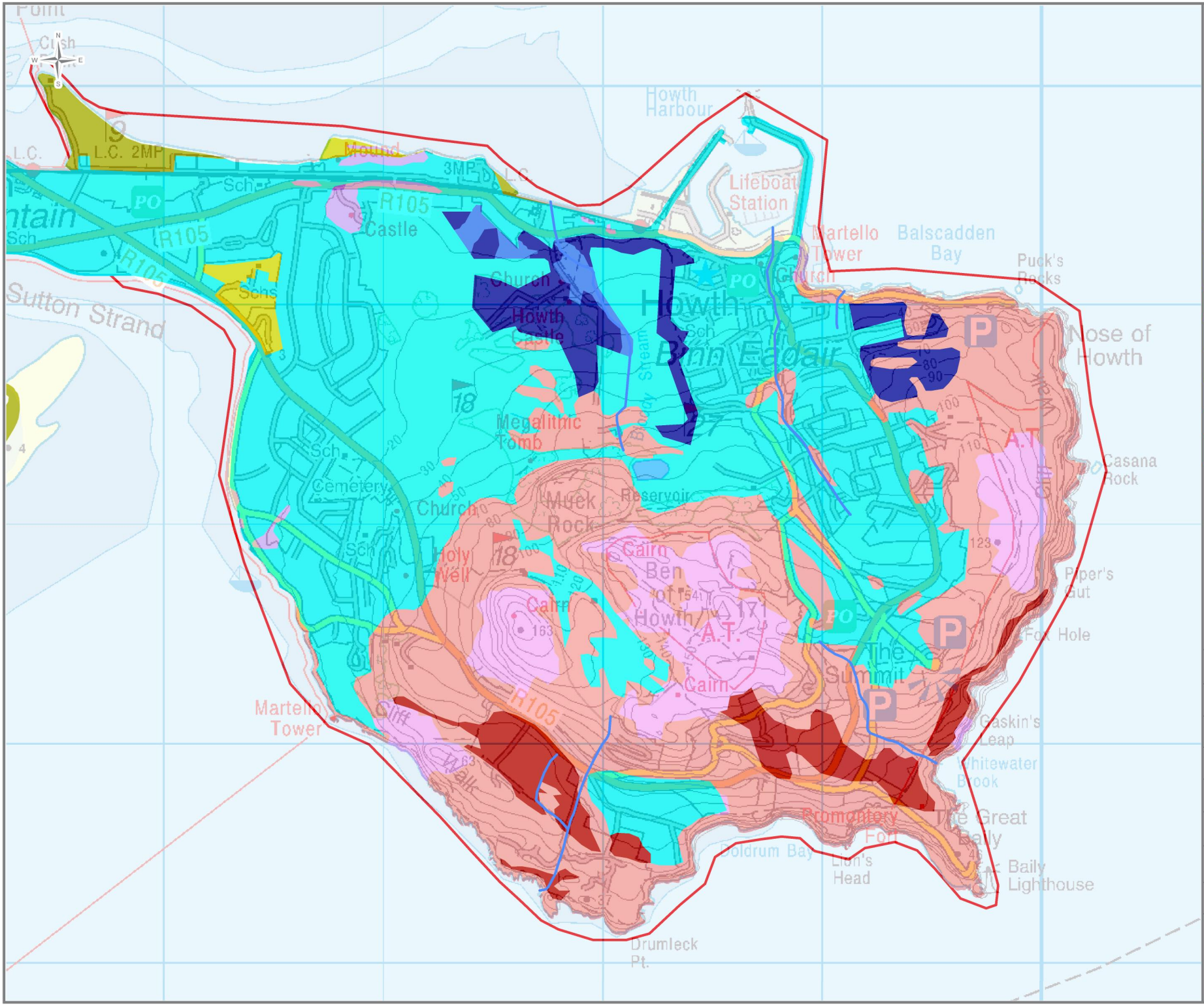

Fig. 5:	General Soils Classification
Date:	November 2020
No.:	1779
Author:	C. O'Reilly
Scale:	1 : 22 500
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co. Dublin

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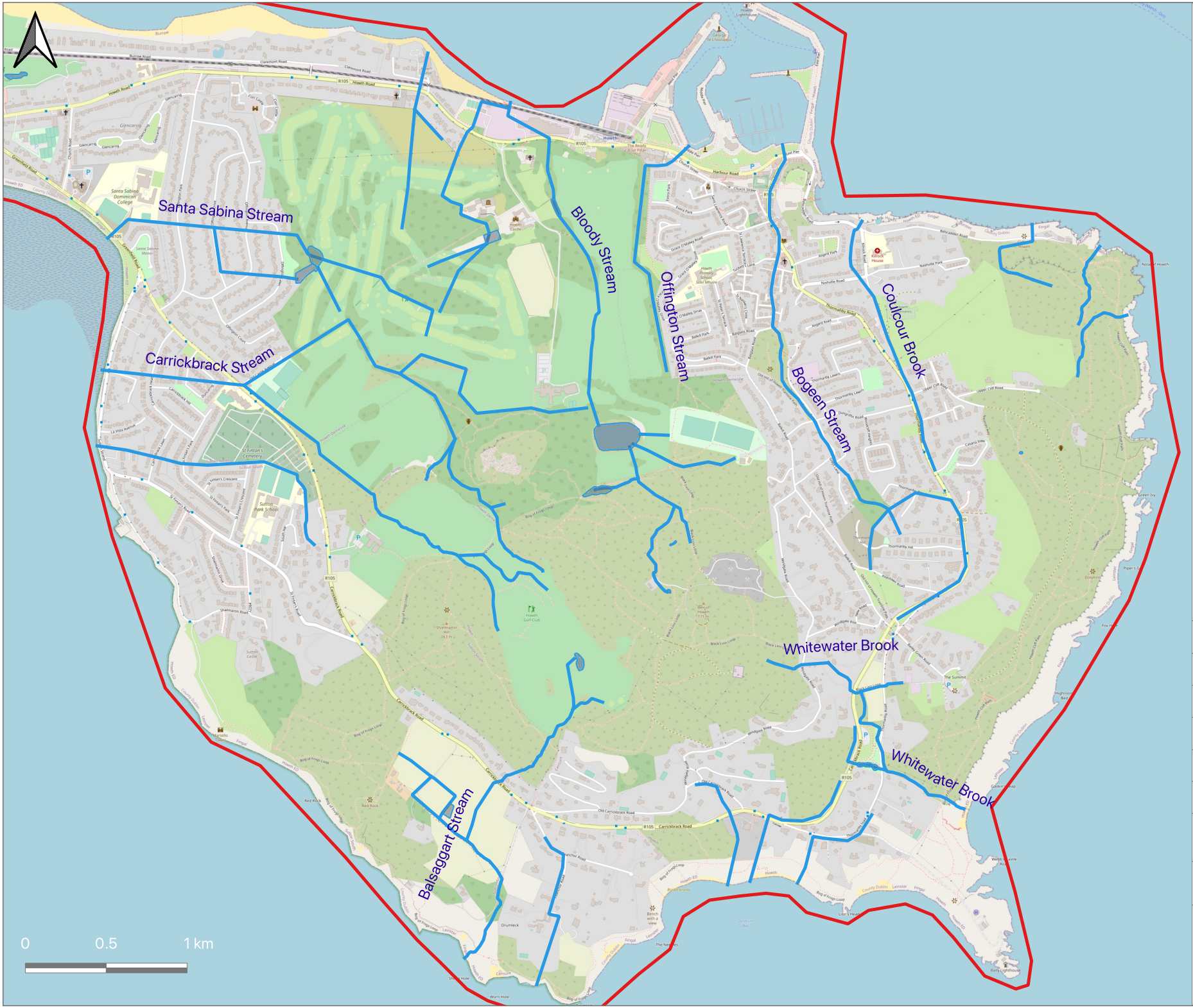

Legend:

- Study area
- Howth Watercourses

Figure 6:	Howth Watercourses
Date:	January 2021
Project:	1779
Author:	COR
Scale:	1: 30,000
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co.Dublin

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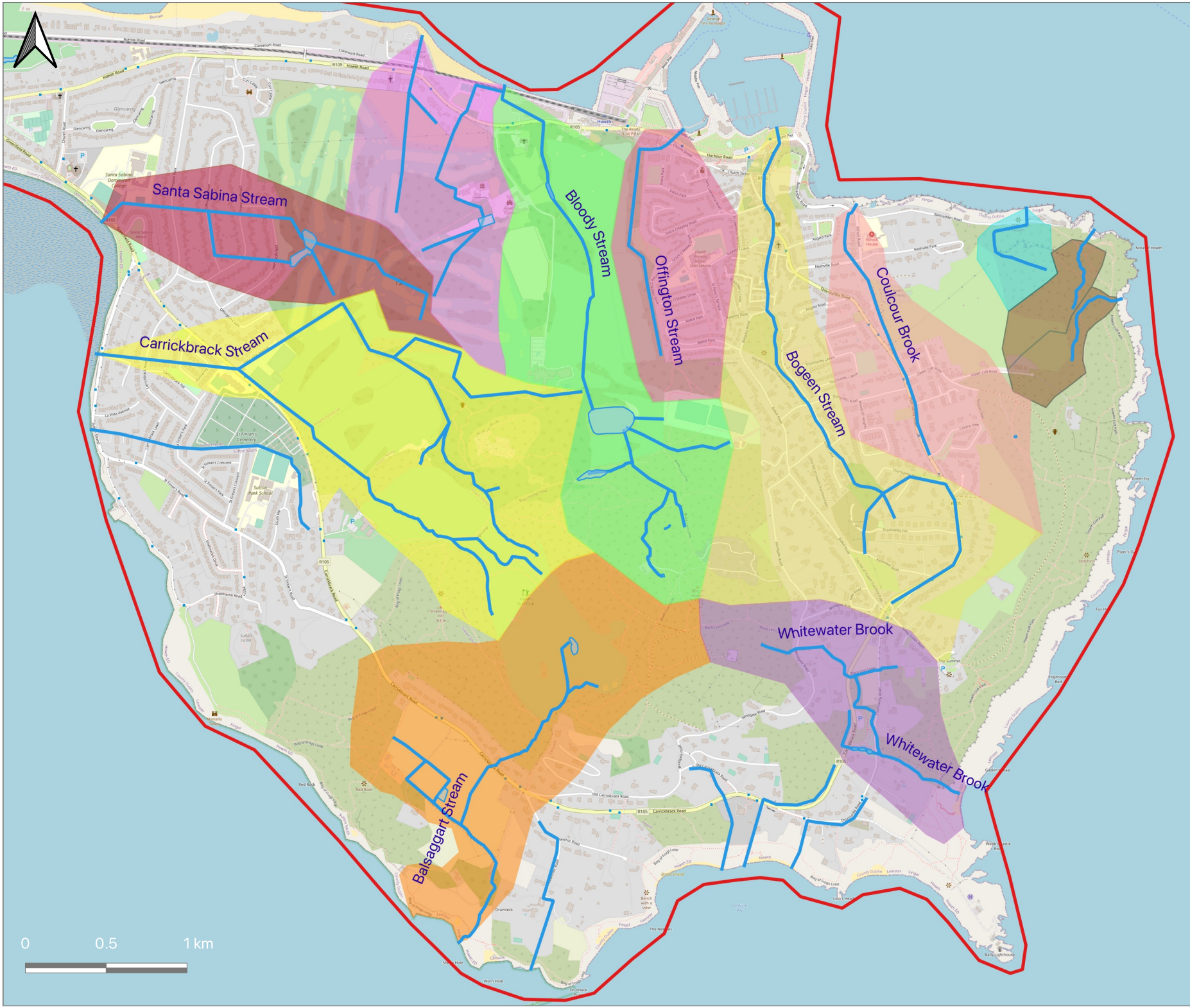

Legend:

- Study area
- Howth Watercourses
- Bloody Stream
- Offington Stream
- Bogeen Stream
- Coulcour Brook
- Kilrock Quarry Area
- Nose of Howth Streams
- Whitewater Brook
- Balsaggart Stream
- Carrckbrack Stream
- Santa Sabina Stream
- Castle Streams

Figure 7:	Catchments Map
Date:	January 2021
Project:	1779
Author:	COR
Scale:	1: 30,000
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co.Dublin

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Legend:

Habitat Modification Score

- Pristine (0)
- Semi-natural (0-2)
- Predominantly unmodified (3-8)
- Obviously modified (9-20)
- Significantly modified (21-44)
- Severely modified (45+)
- Culvert
- Unclassified

Figure 8:	Naturalness (HMS) Map
Date:	January 2021
Project:	1779
Author:	COR
Scale:	1: 30,000
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co.Dublin

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Legend:

- Study area
- Howth Watercourses
- Prospective Sampling Points
- Wetland Feasibility Zones

Figure 9:	Proposed Sampling Points
Date:	January 2021
Project:	1779
Author:	COR
Scale:	1: 30,000
Client:	Fingal County Council
Project:	Hydrology of Howth Wetlands
Location:	Howth, Co.Dublin

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Appendix A - Site Hydrology Sheets

Site 1 - Bloody Stream Catchment

Site 1A - Greenhollows Quarry

Greenhollows quarry is a mainly disused open pit excavation shown on historical maps to be within an area marked as Loughoreen Hills and occupies an approximate area of just over 2 hectares. Envirologic attempted to carry out a walkover survey of the quarry on separate occasions however no operators were present. The front perimeter of the site is securely fenced to restrict public access. The quarry has not been groundtruthed. Given that disused quarries can often provide wetland habitats it is worth formally arranging a site visit with the quarry owner to enable a hydrological and botanical survey to be carried out.

Site 1B - Greenhollows Cottage

Historical maps show presence of a building at this location, 150 m northwest of the telecommunications mast. Planning permission was granted in 1994 for construction of two cottages to replace those damaged in a fire. The cottages are located within a minor valley which trends northwards between the telecommunications mast and the area east of Bog of Frogs, ultimately draining into Howth Castle Demesne Reservoir. The area around the two cottages includes a pond and a small channel. It is assumed that there are not natural. This area was surveyed as part of the botanical survey. Envirologic followed up to perform the hydrological assessment on 29th October 2020, however permission was not granted for access to the wetland areas. Due to uncertainty around the boundary of ownership Envirologic did not assess the wet depressions to the east (AFHowthR_2, AFHowthR_4, AFHowthR_5). Pressures to water quality include septic tanks and percolation areas serving the cottages for the treatment and disposal of domestic effluent. This is particularly pertinent given the general lack of overburden in the area.

Site 1C - Goat Pond

Feature Name	**Goat Pond**	**Type of Feature**	**Historical Quarry Pit**
Survey Date	28/09/20 & 28/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,363 / 737,882	**Location**	250 m north of telecommunication mast
Area	125 m^2	**Ground Elevation**	138 mOD

Bedrock	Cambrian: Mixture (Elsinore)	**Proximity of Structural Fault**	350 m northwest
Subsoil	Quartzite till	**Soil**	Poorly-drained with peaty topsoil (podzol)
Exposures	Perimeter of pond		
SW Catchment	Bloody Stream	**Upgradient catchment**	< 0.2 ha
Water Levels	28/09/20 = 137.49mOD; 28/10/20 = 137.57 mOD		
Depth	approx. 300 - 500 mm		
Inflows	Direct rainfall and small potential inflow channel from fenced goat enclosure to the west.		
Drainage Pattern	The pond occupies an enclosed topographical depression, most likely resulting from historical quarrying. Pond base is a peaty substrate.		
Outflows	No discrete outflow observed. Water level likely controlled by a bedrock fracture, with water leaking to a 3-6 m deep horseshoe shaped depression 10 m to the northeast.		
Hydrochemistry	C = 85 µS/cm; T = 9.5 °C; pH = 7.3*; ORP = 395 mV; DO = 96%*.		
Issues	Faecal matter entrained in runoff from goat enclosure. Goat enclosure not in use anymore.		
Measures	None		

Site 1D - Bog of Frogs

Feature Name	**Bog of Frogs**	**Type of Feature**	**Small raised valley peat bog**
Survey Date	05/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,080 / 738,080	**Location**	Centre of peninsula
Area	2,300 m² (though the actual area of saturated peats is difficult to define due to overgrowth)	**Ground Elevation**	101.5 - 102 mOD in base of depression. Surrounding perimeter = 102 mOD or greater

Bedrock	Cambrian: Quartzite/mudstone (Drumleck)	**Proximity of Structural Fault**	Through site, and valley within which it lies, on a southwest-northeast axis
Subsoil	Thin or absent.	**Soil**	Peaty (recent gorse fire means all substrate in area was black in colour)
Exposures	Bedrock exposed at surface on steep slope immediately south (Dun Hill).		

SW Catchment	Bloody Stream	**Upgradient catchment**	5 ha
Water Levels	101.66 - 101.76 mOD (no detectable hydraulic gradient)		
Depth of water	150 - 300 mm		
Inflows	No discrete inflow observed. Diffuse runoff from elevated lands to the south is the primary inflow. These waters are directed across the public walking trail through at least six recently installed stone crossings, and PVC culverts, which appears successful in restricting erosion. Also runoff from the south-facing side of the valley within the woodland to the west. Seepages from bedrock exposed on the escarpment to the southeast (seepages unconfirmed and not considered to be significant). Direct groundwater flow to bog via transition zone or fault zone (unconfirmed). Although the areas topographically upgradient of the bog are not insignificant it is unclear whether these waters all reach the bog or are intercepted by drainage infrastructure.		
Drainage Pattern	Historical maps do not show any indication of the Bog of Frogs being a waterlogged area though ground to the immediate north was inferred from maps as being marshy prior to reservoir construction. The bog occupies an enclosed topographical depression at the base of a steep outcrop that corresponds with a major fault zone. Sediment, organic matter and debris from gorse fires can be washed down into the depression. The area at which water level is at or above surface is difficult to confirm, but broadly corresponds with the area of birch trees (see above image). A small 300 mm wide open drain exists inside the northern perimeter of the bog. The continuity of this drain is unconfirmed due to overgrowth but is was likely dug to reduce water levels. A pumphouse was observed in the wooded area 300 m west of this site; it is unclear if there is any connection between the bog and this structure.		
Outflows	The outflow was difficult to confirm due to heavy overgrowth but is assumed to be an easterly continuation of the channel inside the northern perimeter. Bed elevation in the outflow channel at the eastern end of the bog was 101.58 mOD. Water is subsequently directed to a confluence 100 m further east where it meets water coming from the Greenhollows area. A separate drainage channel north of the bog serves the golf course (flow 1.5 l/s) and it is assumed there is no subsurface connectivity between this drain and the bog, though this requires further confirmation. These merged channels enter a 200 mm concrete culvert (IL = 95.5 mOD) that transmits water to the nearby reservoir.		
Hydrochemistry			

Pressures	Local drainage infrastructure is the primary pressure impacting the bog. The impact of drainage can be threefold with mechanisms including (i) interception of the natural inflows such that they bypass the bog altogether, (ii) lowering of groundwater levels due to nearby open and subsurface drains such as those serving the adjacent golf course, and (iii) open drainage channels within the bog which are lowering water levels in the bog directly. Water quality pressures include residue from gorse fires and erosion from nearby walking trails, though mitigation measures are now in place to address the latter.
Measures	Topographical survey to confirm natural topographical surface water catchment. Probing using a hand auger to confirm extents and depths of peat substrate (if this is deemed important for ecology). Remove scrub to clarify outfall channel route, invert levels, level control, etc. Also confirm minimum continuous level of perimeter berm and ensure no other outlet pipes. Explore feasibility of installing a cofferdam/weir on the outlet channel to raise water levels in the bog. Need to ensure all perimeter berms are continuous to a level above weir top. Given public access to area there may not be scope to increase water depths significantly. Topographical survey of bog and immediate area to confirm variation in wetted extents as a function of water levels. Calculate gain in wetted area from raising water levels. Explore feasibility of increasing current contributing catchment area to the bog by redirecting drains, e.g. woodland to the west, Greenhollows area. Consider installing water level logger to monitor seasonal water levels and qualitatively measure efficacy of any measures implemented.

Site 1E - Bloody Stream

Feature Name	**Bloody Stream**	**Type of Feature**	**Natural Stream**
Survey Date	01/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,993 / 738,978	**Location**	Howth Castle Demesne

Bedrock	Upper catchment: Cambrian quartzite/ mudstone Lower catchment: Limestone	**Proximity of Structural Fault**	Two faults mapped south of Howth Castle
Subsoil	Limestone till & limestone gravels	**Soil**	Deep well-drained basic mineral
Exposures	None		
Channel Length	1,300 m (reservoir to coastal outfall)	**Catchment to Outfall**	80 ha
Channel Dimensions	On approach to Howth Castle the stream passes through a stone arched culvert with dimensions: width = 0.9 m, spring height 0.8 m, soffit height 1.1 m. Downstream of the culvert open channel has dimensions: bed width = 1.5 m, bank height = 2.5 m, banktop width = c. 5 m. Bed substrate is clay, with some cobbles and boulders which seem out of place, and are assumed to be remnants of historic bank reinforcement. Bank sides are firm, steep and relatively bare in terms of vegetation. Some undermining of the stream banks has occurred. Downgradient of Black Jack's Pond the stream has similar cross-sectional profile, if slightly deeper.		
Water Levels	Not surveyed - lack of signal due to heavy canopy cover.		

Gradient	Moderate
Inflows	The catchment commences on the raised ground at Muck Rock. The primary inflow to the stream is the outflow from Howth Reservoir, after which the stream is culverted for 500 m. Other inflows include (i) runoff and subsurface drainage from the greenfield area within Deerpark estate to the east of the stream, (ii) runoff and subsurface drainage from the agricultural grassland field directly south of the Castle, (iii) hardstanding runoff from Deerpark Hotel, car park and internal access road.
Drainage Description	The limited open channel section of the Bloody Stream commences in the wooded area on the eastern side of the laneway between Howth Castle and Deerpark Hotel. At the front of Howth Castle the stream tapers off into Black Jacks Pond (Site 10). Approximately 70 m downstream of the pond the stream disappears underground through a small clay berm, it being assumed that there is a collapsed culvert structure beneath/behind the berm but this was not observed. It's clear that when this structure gets inundated water levels quickly reach 1 m depth, reportedly flowing across the surrounding area before re-entering the culverted channel at an unidentified point downstream. A 600 mm culvert within a brick-built 2 m deep underground chamber was observed approximately 15 m south of the Howth Road. The culvert outfalls at a clearly visible cascade on the southern road embankment before re-entering a culvert which transmits water to its final outfall on Claremont Beach.
Proportion Culverted	68%
Primary Outflow	The stream outfalls on Claremont Beach.
Hydrochemistry	
Issues	Inadequate capacity upstream of Howth Road which may increase risk of flooding on Howth Road. Increased flows from future development works, specifically altered contributing catchment, increased hardstanding area, altered subsurface drainage network. Subsurface drainage infrastructure within Howth Demesne is old and has been altered at various intervals in the past. Some undermining of stream banks upgradient of pond.
Measures	Regular inspection of stream banks to ensure structural stability. Consider commissioning a small project to assist groundsmen at Howth Demesne to develop a current drainage map. Reinforcement works on stream banks not considered urgent but a biannual inspection and maintenance programme regarding structural integrity recommended. Further investigate buried culvert inlet c. 70 m downstream of pond. Consider de-culverting channel between reservoir and Black Jacks Pond.

Site 1F - Howth Demesne Reservoir

Feature Name	**Howth Demesne Reservoir**	**Type of Feature**	**Constructed Reservoir**
Survey Date	05/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,144 / 738,272	**Location**	Centre of peninsula
Area	14,200 m^2	**Ground Elevation**	c. 90 mOD

Bedrock	Cambrian: Quartzite/mudstone (Drumleck)	**Proximity of Structural Fault**	100 m south
Subsoil	Limestone till	**Soil**	Shallow, well-drained acidic mineral
Exposures	Muck rock, 200 m south		

SW Catchment	Bloody Stream	**Upgradient catchment**	28 ha
Drainage Pattern	Not present on 6" or 25" OSI maps. An area referred to as Ballykill Bog is shown at this location on Cassini maps. The reservoir was a holding pond used to store water for potable and irrigation supply to Howth Castle Demesne. The reservoir likely also serves to attenuate flashy runoff from raised ground to south following heavy rainfall. The perimeter of the reservoir is defined by a raised embankment.		
Water Levels	86.81 mOD		
Depth	Unconfirmed.		
Inflows	Diffuse runoff from Greenhollows area and a discrete outflow from Bog of Frogs merge at a confluence 100 m south of reservoir, before entering a 200 mm concrete culvert. This culvert enters on the southern side of the reservoir. Separately, water collected at the toeslope of raised ground directly south of Beann Eadair GAA club grounds is transmitted in an east-west open drain. This water enters a culvert beneath a recently installed boardwalk at the southwestern corner of the GAA pitch before being diverted to the southeastern corner of the reservoir. Aerial photography also infers a dedicated drain serves the subsurface drainage network beneath Beann Eadair GAA playing pitches. Inflows from the woodland area to the west appear to be diffuse but closer inspection is required to confirm this.		
Outflows	Outflow is at the northwest corner of the reservoir. A vertical concrete tower is clearly evident protruding out of the reservoir. This is understood to be the sluice housing which controls outflow rates from the reservoir. The outlet pipe invert level Is unconfirmed. The main pipe from the sluice flows directly north and forms the headwater of the Bloody Stream. The sluice facilitates a water supply to an open, overground tank at the rear of Deerpark Hotel.		
Hydrochemistry			
Issues	Concerns that if the outflow sluice mechanism ever failed there is no back up system to control reservoir outflow.		
Measures	Perform inspection of sluice mechanism to confirm invert level of reservoir. In order to protect against future flooding of Howth Road insist on any future development works within Deerpark and in close proximity to Bloody Stream to inspect sluice and install backup flow control device. Install water level logger to confirm degree of water level fluctuation in reservoir. This is important to better understand maximum potential release of uncontrolled water in event of sluice failure.		

Site 1G - Black Jack's Pond

Feature Name	**Black Jack's Pond**	**Type of Feature**	**Artificial Pond**
Survey Date	01/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,891 / 739,110	**Location**	Front of Howth Caslte
Area	850 m²	**Ground Elevation**	18.05 - 19.15 mOD

Bedrock	Impure limestone (Ballysteen)	**Proximity of Structural Fault**	200 m south (Cambrian/Limestone)
Subsoil	Limestone gravels	**Soil**	Deep, well-drained basic mineral
Exposures	Not in immediate vicinity		

SW Catchment	Bloody Stream	**Upgradient catchment**	72 ha
Water Levels	17.33 mOD		
Depth	Pond bed at the upgradient face of the northern wall, and at the perimeter, was encountered 0.45 m below water level, and 1.4 m below walltop. This suggests there may be up to 1 m of sediment in the pond base.		
Inflows	There is no inlet structure. In effect the Bloody Stream open channel just tapers into the southern end of the pond.		
Drainage Pattern	Black Jack's Pond is clearly indicated on all historical maps. The Howth Castle ACA Statement of Character report (Fingal County Council, undated) describes how the circular hollow just to the west of the pond marks the site of Black Jack's Well.		

Outflows	A 2.5 m high shuttered concrete wall impounds the pond at its northern end. The wall contains a small 150 mm sluice flap, controlled with a corkscrew-type mechanism. This is permanently closed. Two additional 2.5 m walls are in place across the stream channel 15 and 30 m downstream of the pond. These dams likely served the purpose of impounding water for irrigation in the walled gardens which occupied the area northwest of the pond. The walls house old sluice valves along with openings on their eastern side which appear to have been broken out.
Hydrochemistry	
Issues	The inlet to the pond is very muddy and presumably high velocity stream flow caused by the steep channel gradients has transported a lot of sediment and debris into the pond from the upgradient catchment and bank erosion. The impounding wall is breached through overburden and tree roots on its eastern side. Flow observed leaking through the breach was estimated as 0.5 l/s, this being broadly equivalent to inflow on the day; it is unclear if there is throttling effect here to withstand larger inflows. Structural failure of any retaining walls would reduce attenuation capacity of pond thereby increasing downgradient flood risk.
Measures	Dredge the inflow area to the pond. Consider altering the stream bed to dampen flow velocities on approach and installing an inlet structure with an overflow that would allow sediment to settle out of solution and be removed regularly. This would provide a more confined chamber for entrapping and removal of sediment/debris. Consider dredging the entire pond. This would facilitate a more suitable target depth of water for particular species, shelfing within pond. There is estimated 1 m of sediment in downstream (northern) end of pond. Remove fallen trees from impoundment walls to prevent structural damage. Repair the breach on eastern side of pond impoundment wall. This would raise pond water levels by 1 m (if desirable). Repair sluice in impoundment walls to complement measure 4. Calibrating the sluice would enable the pond to attenuate higher inflows. Similar rehabilitation of the two downgradient dam walls would allow targeted water depths in the stream intervals which could be used to target different plant species.

Site 2 - Offington Stream Catchment

Site 2A - Offington Stream

Feature Name	**Offington Stream**	**Type of Feature**	**Stream**
Survey Date	29/01/21	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,421 / 738,877	**Location**	Old Tram Line

Bedrock	Cambrian Quartzite & mudstone (Drumleck) & limestone (Ballysteen)	**Proximity of Structural Fault**	Southeast-northwest fault crosses catchment
Subsoil	Sandstone/shale gravels & limestone till	**Soil**	Deep, well-drained basic mineral
Exposures	None within catchment.		
Channel Length	1,110 m	**Catchment to Outfall**	36 ha
Channel Dimensions	Generally bed width = 0.5 m, bank height = 1.0 m, banktop width = c. 3 m. Bed substrate is clay. Evidence of fly-topping in numerous areas. Three public crossings are unmaintained but public access could be soon restricted due to proposed development works.		
Water Levels	Water level greater than 100 mm was not observed at any point. Stream is dry most of the year.		
Gradient	Moderate and relatively consistent.		
Primary Inflows	Diffuse from wooded area north of Binn Eadair GAA. Runoff from hardstanding in remainder.		
Drainage Description	Diffuse drainage from wooded area in upper catchment and a small area in Howth Demesne. The greenfield area within the remainder of the catchment is small and any additional flows are assumed to be rainfall/runoff generated from hardstanding within Balkill Park, Grace O'Malley Drive/Road and Evora Park. The stormwater network layout serving these residential areas, and the outfall locations from same, are unconfirmed.		
Proportion Culverted	15% of channel culverted. Proportion of catchment culverted is unconfirmed.		
Outfall	Reportedly middle harbour but not observed.		

Pressures	Fly-tipping. Erosion at pedestrian crossings. Alterations as part of future development works. Uncertainty in contributing area due to lack of stormwater drainage network maps.
Measures	Clean channel and upgrade any informal pedestrian crossing points.

Site 3 - Bogeen Stream Catchment

Site 3A - Thormanby Woods

Feature Name	**Thormanby Woods**	**Type of Feature**	**Woodland**
Survey Date	08/10/20 & 14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,090 / 738,050	**Location**	Northwest of Thormanby Hill residential estate
Area	1.43 ha	**Ground Elevation**	87.8 - 91.5 mOD

Bedrock	Cambrian: Greywacke sandstone (Pipers Gut Formation)	**Proximity of Structural Fault**	Synclinal axis mapped northwest-southeast through centre of feature. Fault corresponds with valley
Subsoil	Quartzite till	**Soil**	Shallow well-drained acidic mineral
Exposures	Large cutaway out of north-facing embankment in construction area south of woods. Exposure shows competent bedrock, weathered bedrock, transition zone and gravelly till.		

SW Catchment	Bogeen Stream (Gray's Stream)	**Upgradient catchment**	41 ha
Historical Drainage Pattern	The woods occupy a naturally enclosed depression at the foot of a short, southeast-northwest valley, which forms the headwaters of the Bogeen Stream. The woods are commonly referred to in various historical reports as being damp/wet. Within the woodland itself the primary watercourse runs east-west, almost bisecting the site, and was originally fed by several ditches capturing runoff from upgradient grassland fields. The 6" and 25" maps indicate a spring immediately south of the woods with discharge carried to the primary watercourse via a short northbound channel. Historical maps also show a spring on higher ground on the southern side of the Kitestown Road.		
Water Levels	Water level in the primary watercourse through wood = 87.8 mOD; Water levels in ponded area in eastern area of wood = 88.7 - 90.0 mOD; Groundwater seepage zone on exposed embankment to south = 99 - 100 mOD.		
Current Inflows	Numerous seepages and small discrete spring outflows are clearly visible emerging from the transition zone on the embankment to the south which has been exposed during site clearance works. These seeps are all captured, channelised and diverted towards a temporary 200 mm culvert beneath the internal haulage road in the construction area. This culvert also accepts water (estimated 6 l/s) from a 250 mm pipe beneath Kitestown Road. The outfall of the 200 mm on-site culvert appears to be the open channel along the eastern boundary of the woods, though this is not confirmed. Flow from an unmaintained channel along the western boundary of the woods was approximately 2 l/s. This may be the discharge from the mapped spring described above. Flow in the drain along the western side of the current houses was minimal and estimated as 0.2 l/s.		
Current Drainage Pattern	The site must be considered in the context of recent development of a residential housing estate constructed directly southeast and topographically upgradient. Planning permission is in place for additional houses to the south which is currently a construction area with exposed soils. Historical channels within the completed area were re-aligned with no issues observed. Significant development works have also taken place within the woods. These include installation of a 200 mm concrete culvert bound by concrete headwalls at either end. This culvert appears to transmit runoff from the western half of the current construction area. A 200 m looped pentagonal gravel track has been laid in the centre of the woodland. Additional path/roadway has been installed in the western half of the woods. These may have been installed to facilitate construction of culverts, headwalls and new channels. The path surface consists of compacted gravel and sits on ground level of 89 - 90 mOD. Depending upon the depth of this path/roadway it has the potential to impede shallow groundwater flows. An attenuation device is shown on planning drawings below the compound area. The outfall from this appears to be piped to the primary woodland drain. The current inflow to this is unclear but it may carry grey water from the site compound area. There is an area of significant ponding in the eastern half of the woods. The source of this water is unclear: it may be representative of pre-development hydrological regime, or it may be shallow groundwater rising to surface due to flow impedance as a result of recent works.		
Current Outflows	Outfall structure midway along western boundary of woods = 600 mm diameter culvert; IL = 87.25 mOD; flow = c. 10 l/s. Trash grate is in place upstream of culvert. A 450 mm corrugated PVC pipe is in place beneath a recently installed vehicular crossing immediately upgradient of the outfall.		
Hydrochemistry	Groundwater seeps on embankment: C = 310 µS/cm; T = 12.2 °C; pH = 8.0*; ORP = 243mV; DO = 86%. Outflow: C = 406 µS/cm; T = 13.3 °C; pH = 8.6*; ORP = 229mV; DO = 76%. Groundwater chemistry displays lower pH and conductivity relative to the surface waters leaving the site.		

Pressures	Prior to recent development works the woods were most likely fed by shallow groundwater flow in the transition zone from upgradient areas. This shallow groundwater would enter the woods either directly at the subsurface root zone or emerging to surface at the pre-development toeslope before flowing the short distance overland into the woods. As a result of the embankment excavation this shallow groundwater now emerges to surface on the exposed face to the south in the form of a series of seeps and small springs. The interception and channelisation of these groundwater seeps and springs deprives the woods of the previously diffuse flows and associated groundwater chemistry controls. The chemical signature of this groundwater changes significantly as it flows over surface and through culverts. The lack of this groundwater inflow will alter the hydrochemistry of water within the wooded area and parts of the woods may become drier, accelerated by the increased number of drainage channels. The pentagonal gravel track in the woods may further disrupt shallow groundwater flow paths.
Measures	An undeveloped buffer zone has been recently installed around the spring south of the woodland. This should be retained in place. Blocking drains to increase surface water levels in the woods is unlikely to rewet the woods or reverse the drying out process caused by channelisation. It will merely lead to more permanent waterlogging and the negative effects this will have on tree growth. The change in hydrochemistry may also have a negative impact on species diversity. Attempts could be made to mimic the old spring-fed hydrogeological regime by trying to redistribute the channelised flow, captured upgradient of the woods, into a more diffuse pattern. It's difficult to say with any certainty if this would be successful. A more considered comparison of maps and drawings showing pre-development drainage, planned construction drainage, and current drainage may prove useful in gaining knowledge about likely alterations that have occurred in relation to groundwater levels, flows and chemistry. Given uncertainty on when construction will resume in the area south of the woods some interim measures could be implemented. This would include installing headwork to house the current 200 mm culvert. Sedimental control measures to treat groundwater and runoff flowing across the construction compound and into the woods is essential. Detailed mapping of the current drainage infrastructure across the site is required. This would include confirmation of the outlet point of the 200 mm culvert and the potential source of ponding in the eastern half of the woodlands. Long-term monitoring of groundwater levels and quality on the embankment and within the woods could be facilitated by installation of piezometers. This should be considered to establish a baseline of water quality prior to further construction. Local authority to consider taking the woodland area in charge. There is mention in previous planning documentation of a willingness for the developer to transfer the woodlands into public ownership by way of a planning condition. Issues regarding suitable access were highlighted as limiting factors.

Site 3B - Bogeen Stream

Feature Name	**Bogeen Stream (Gray's Brook)**	**Type of Feature**	**Stream**
Survey Date	12/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,738 / 738,628	**Location**	Thormanby Woods to Howth Harbour

Bedrock	Cambrian greywacke (majority of catchment)	**Proximity of Structural Fault**	Mapped as passing over two SW-NE faults
Subsoil	Quartzite till / Sandstone gravels / Limestone gravels	**Soil**	Shallow, well-drained acidic mineral
Exposures	Lower half of catchment is urbanised. Some exposed bedrock on western side of stream adjacent to Dungriffin Villas.		

Channel Length	1,400 m	**Catchment to Outfall**	97 ha
Channel Dimensions	Gray's Lane: bed width = 0.5 m, bank height 1 m, bank top width 3 m. Dungriffin Villa's: bed width = 0.75 m, bank height 2 m, bank top width 4 m.		
Water Levels	87.03 - 84.44 mOD along Gray's Lane; 80.31 - 50.07 mOD between Dungriffin Road and Balglass Road; Inaccessible from Balglass Road to outfall.		
Gradient	Gray's Lane = moderate; Dungiffin Road - Harbour = steep		
Primary Inflows	Outfall from Thormanby Woods (Site 1) via 600 mm diameter culvert; IL = 87.25 mOD; flow = c. 10 l/s. Stormwater network along route.		
Drainage Description	As the stream flows through the Gray's Lane area it is culverted beneath the entrance to several residences. These culverts are composed of a variety of structure types and orifice sizes, generally set within cast/block headwalls. It is unclear if these culverts contribute to flood risk. Upgradient of Dungriffin Road the stream flows along a constructed stone channel within private gardens, which includes a number of small weirs and pools. Vegetation varies from maintained grass verges and scrub in fenced off areas. Downstream of Dungriffin Road the channel steepens significantly and the profile changes accordingly. Bank vegetation changes to gorse and bracken. Bed substrate becomes coarser, composed of angular cobbles and boulders. The channel enters a short culvert crossing Dungriffin Villas adjacent to the Irish Water compound, where flow was estimated as 50 l/s. At the transition of Balglass Road to Main Street the stream enters a culvert which carries flow along Main St. to the outfall point. This culvert inlet was not observed due to heavy scrub cover. The stream has reportedly surcharged in the past at iron manhole covers along Main Street following intense rainfall.		
Proportion Culverted	50%		
Outfall	Howth Harbour just east of Howth Yacht Club clubhouse, submerged during high tide.		
Hydrochemistry	Dungriffin Villas: C = 459 µS/cm; T = 14.8 °C; pH = 8.0*; ORP = 281 mV; DO = 81%*.		
Pressures	Potential flooding due to channelisation of flow in upgradient catchment area (Thormanby Woods) and variety of culvert crossings.		
Measures	Consider removal of scrub and planting maintained grass banks where stream passes through Gray's Lane. Clean all culvert inlets and outlets of vegetation and include same in regular inspection programme.		

Site 4 - Coulcour Brook Catchment

Site 4A - Coulcour Brook

Feature Name	**Coulcour Brook**	**Type of Feature**	**Stream**
Survey Date	12/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,169 / 738,575	**Location**	Cowbooter Lane

Bedrock	Cambrian: mixed (Elsinore)	**Proximity of Structural Fault**	Southwest-northeast faulting terminates as breccia observed northwest of stream outfall.
Subsoil	Limestone till / Quartzite till / Limestone gravels	**Soil**	Shallow, well-drained acidic mineral
Exposures	Steep north-facing cliff face at outfall shows clean orange/brown greywacke, massive structure. Heavily weathered and deformed bedrock west of outfall. Overburden at coastal cliff is a 5 m thick, gravelly clay till, resembles conglomerate.		
Channel Length	600 m	**Catchment to Outfall**	47 ha (natural) though much runoff is captured by mains stormwater network.
Channel Dimensions	Channel is largely inaccessible along its entire route.		
Water Levels	Top of Cowbooter Lane = 69.72 mOD.		
Gradient	Same gradient as Cowbooter Lane. Graident shallows out for a short distance upgradient of Balscadden Road.		
Primary Inflows	Fed by diffuse runoff from exposed hilltop in Upper Cliff Road area, stormwater network serving roads and hardstanding may outfall to stream (unconfirmed).		
Drainage Description	The upper catchment boundary is not easy to delineate. Runoff passes through the Upper Cliff Road area of houses before entering open channel at top of Cowbooter Lane. Close to where it passes the allotments the stream is culverted from the eastern to western side of Cowbooter Lane from where the culvert continues behind a stone wall as far as Nashville Road. Between Nashville Road and Balscadden Road stream flows through rear gardens of private residences.		
Proportion Culverted	25%, between lower Cowbooter Lane and Nashville Road.		
Outfall	Inaccessible. Stream is culverted beneath Balscadden Road prior to coastal outfall through narrow gorge in steep cliff.		
Pressures	No significant pressures identified.		
Measures	Consider clearing scrub from channel and planting riparian margin.		

Site 4B - Upper Cliff Road Pond

Feature Name	**Upper Cliff Road Pond**	**Type of Feature**	**Enclosed depression on hilltop**
Survey Date	28/09/20 & 12/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,637 / 738,251	**Location**	Track extending south from main Upper Cliff Road walking trail.
Area	58 m^2	**Ground Elevation**	Perimeter > 117.00 mOD

Bedrock	Cambrian: mixed (Elsinore)	**Proximity of Structural Fault**	East-west syncline 250 m south
Subsoil	None	**Soil**	Thin, acidic podzol (peaty)
Exposures	Quartzite bedrock exposed at surface around pond perimeter		
SW Catchment	Coulcour Brook	**Upgradient catchment**	None
Drainage Pattern	Not marked on any historical maps. Difficult to ascertain if pond occupies a natural topographical enclosed depression or if there was minor historical excavation (presume the latter). No discrete inflow or outflow.		
Water Levels	116.99 mOD		
Depth	Base = 116.61 mOD, depth = 0.38 m.		
Inflows	No discrete inflows. Direct rainfall and runoff from a small area of exposed bedrock supply pond.		
Outflows	Lowest ground level on perimeter is adjacent path, pond overtops west across this path when water level exceeds 117.00 mOD. Route from pond to Cowbooter Lane unconfirmed.		
Hydrochemistry	Water dark, peaty in colour. C = 147 µS/cm; T = 13.9 °C; pH = 7.5*; ORP = 273 mV; DO = 62%*. Reflective of rainwater.		
Pressures	None noted		
Measures	Sample water quality here as area is free of pressures.		

Site 4C - Ashbourne House Well

Feature Name	**Ashbourne House Well**	**Type of Feature**	**Shallow well (dry)**
Survey Date	28/09/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,578 / 738,189	**Location**	Field margin 80 m east of Casana View
Area	2 m^2	**Ground Elevation**	115.46 mOD
Bedrock	Cambrian: mixed (Elsinore)	**Proximity of Structural Fault**	East-west syncline 250 m south
Subsoil	None present	**Soil**	Shallow, well-drained acidic mineral
Exposures	Quartzite bedrock exposed on surrounding raised ground		
SW Catchment	Coulcour Brook	**Upgradient catchment**	< 1 ha
Drainage Pattern	Shown on 25" OSI maps, the feature was a 1 m deep, enclosed depression when observed. No evidence of a historical well chamber. Drainage pattern continues northwest towards Coulcour Brook.		

Water Levels	Dry
Depth	Base of depression = 114.32 mOD; depth of depression = 1.1 m.
Inflows	Diffuse runoff from raised ground to the east transmitted through a very small valley along field boundary.
Outflows	Possible arterial drainage channel extending northwest from depression.
Hydrochemistry	N/a
Pressures	None
Measures	None

Site 5 - Kilrock Quarries

Feature Name	**Kilrock Quarry**	**Type of Feature**	**Quarry Voids**
Survey Date	28/09/20 & 12/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,650 / 738,950	**Location**	Northeast corner of peninsula
Area	Northern void = 6,500 m² Southwestern void = 1,950 m² Eastern void = 3,330 m²	**Ground Elevation**	Northern pit floor = 35.5 - 48.85 mOD Southwestern pit floor = 66 mOD Eastern pit floor = 65 mOD

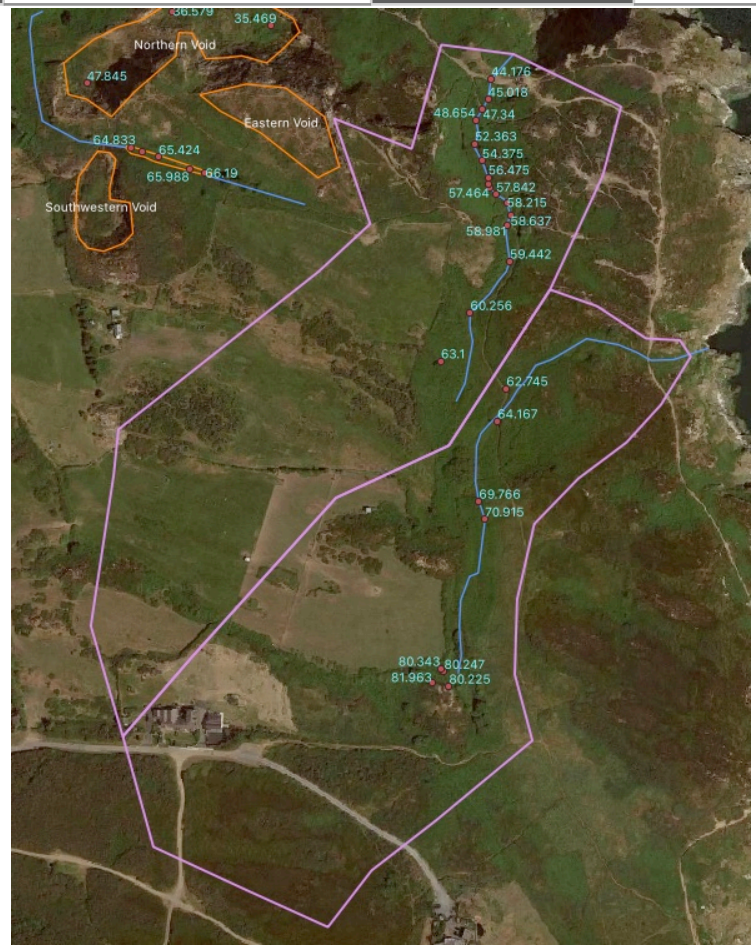
Bedrock	Cambrian: Polymict melange (Elsinore)	**Proximity of Structural Fault**	500 m southwest
Subsoil	Lacking across much of the area. Where present pockets of quartzite till (east) and limestone gravels (west).	**Soil**	Shallow, well-drained acidic mineral to south and east; deep, well-drained limestones to west
Exposures	Quartzite and greywacke bedrock exposed across entire area.		

SW Catchment	Coast	**Upgradient catchment**	Difficult to delineate. Potentially 3 ha.
Historical Drainage Pattern	The massive structure and low permeability of greywacke at Kilrock, combined with the raised landscape position of historical excavations, means it is unlikely that previous activities caused a significant alteration to natural drainage patterns. Historical maps appear to indicate some form of quarry compound or processing facility in the flat area south of the eastern void. No significant quarrying since publication of 25" OSI map.		
Water Levels	Some localised areas of ponding were noted on depressed areas within the pit floors. Water levels in these ponded areas are relieved by lower ground at the mouth of each void. A linear surface water channel was surveyed in the east-west valley running through the quarry area. Water levels were recorded as 66.19 - 64.83 mOD, falling from east to west.		
Current Inflows	Direct precipitation to the voids.		
Current Drainage Pattern	The eastern void is raised relative to surrounding ground and is unlikely to have any groundwater catchment. Similarly, the northern void is raised relative to Balscadden Road and fields to the south. No significant seeps were observed on the 10 m high exposed faces within the northern void, with bedrock here massive in structure. Overburden cover is less than 100 mm. Small topographically enclosed depressions are saturated (presumed to be rainwater) and may display some ponding. Some minor seepages were observed closer to the western end of the northern void. Soils and organic matter washed into these areas have degraded to podzols and peats. The southwestern void is a north-facing horseshoe-shaped depression. The c. 10 m high faces and 5-8 m high gravel spoil heaps at the open northern end protect this void from the elements, when compared to the much more exposed northern pits. The floor of this void appears to be lower than that of peripheral fields. Hence rainfall infiltrating the field surfaces may re-emerge in the faces of this southwestern void. No seeps were observed in the eastern and western faces which are massive in structure. The southern face is less steep and displays some weathering and fracturing; some small groundwater seeps were noted in this southern face though significant gravel spoil at the toeslope obscured closer inspection.		
Current Outflows	Any waters in the southwestern void leave at the open north end and enter the east-west stream. This stream enters a small overgrown valley that wraps around the western perimeter of the area and is assumed to enter a culvert beneath Balscadden Road. This stream also restricts potential for infiltration and subsequent re-emergence of groundwater in the northern void.		
Hydrochemistry			
Pressures	This void is largely undisturbed.		
Measures	Clean gorse and scrub on quarry floors to aid identification of groundwater seeps.		

Site 6 - Nose of Howth

Site 6A - Nose of Howth Eastern Stream

Feature Name	No official reference	Type of Feature	Natural Stream
Survey Date	16/10/20	Surveyed by	C. O'Reilly, Envirologic
Centre Coordinates	729,854 / 738,692	Location	East of Canon Rock



Bedrock	Cambrian quartzite/mudstone (Elsinore)	Proximity of Structural Fault	600 m southwest
Subsoil	Quartzite till (where present)	Soil	Shallow well-drained acidic mineral
Exposures	Prolific exposures along coastal cliffs and adjacent Kilrock quarry.		

Channel Length	360 m	**Catchment to Outfall**	7.5 ha
Channel Dimensions	Small profile, in places 300 mm wide with no significant banking.		
Water Levels	40 - 80 mOD.		
Gradient	Shallow, steepening towards outfall.		
Inflows	The stream appears to rise from a site of ruins located 150 m east of Cannon Rock Cottage and within a horseshoe-shaped depression at the base of a raised bedrock exposure. A well is indicated at this location on 25" OSI maps. There appears to be a 2 m diameter, 2 m deep topographically enclosed depression that may be a shallow well but significant scrub prevented closer inspection. Historic 50 mm cast iron pipework in close proximity reinforces this somewhat though the destiny of this infrastructure is unclear.		
Drainage Description	The stream runs through a shallow valley which drains a relatively small catchment in the northeast corner of the peninsula. This is a typical example of the many small catchments on East Mountain which drain to the coast. 100 m north of the shallow well feature streamflow was estimated as 1 l/s as it passed northwards over a 1 m high, 300 m wide weirtop. The channel then runs through or around a small area of birch trees before turning east where it flows freely over the path. This can promote erosion though the hard rock and small stream dimensions mean that this is unlikely to be a significant issue at this location.		
Proportion Culverted	< 1%		
Primary Outflow	The stream is culverted beneath the lower cliff path via a 200 mm PVC pipe and at 2 l/s outfalls to the sea through a steep, narrow gorge on an east facing cliff.		
Hydrochemistry			
Issues	Source of stream is not well understood. Erosion and sediment mobilisation where stream crosses public walking trail. There are no significant sources of contamination in the area. Some grazing of horses in the catchment but this is very low intensity.		
Measures	Scrub clearance to facilitate closer inspection of potential stream source. Install culvert or raised path section to prevent stream bed and bank erosion.		

Site 6B - Nose of Howth (Northern Stream)

Feature Name	**No official reference**	**Type of Feature**	**Natural Stream**
Survey Date	16/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,867 / 738,872	**Location**	East of Kilrock quarry
Bedrock	Cambrian quartzite/mudstone (Elsinore)	**Proximity of Structural Fault**	600 m southwest
Subsoil	Quartzite till (where present)	**Soil**	Shallow well-drained acidic mineral
Exposures	Prolific exposures along coastal cliffs and adjacent Kilrock quarry.		

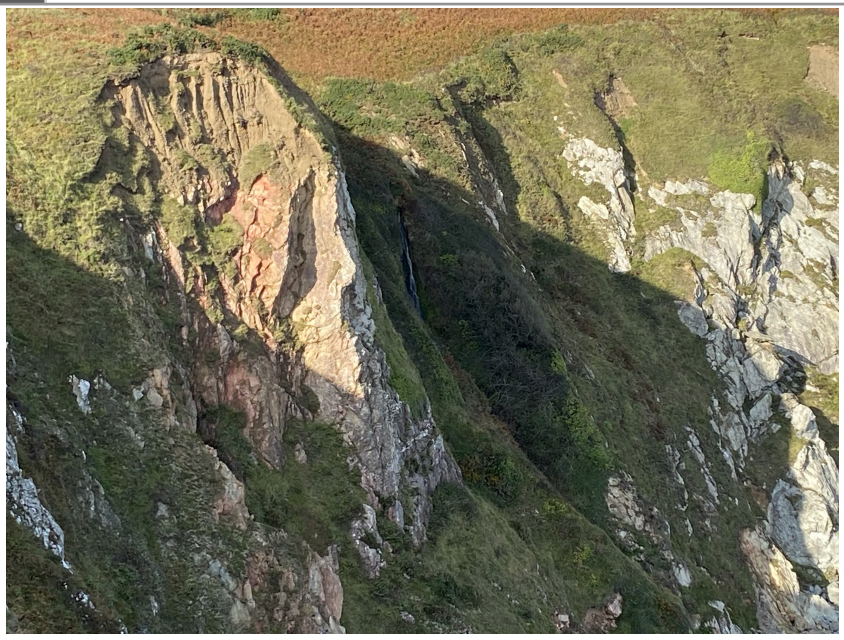
Channel Length	260 m	**Catchment to Outfall**	7 ha
Channel Dimensions	Small profile, in places 300 mm wide with no significant banking.		
Water Levels	44 - 60 mOD		
Gradient	Shallow, steepening towards outfall.		
Inflows	No sign of a discrete inflow, seems to be diffuse runoff from a catchment to the west that includes some agricultural fields used for grazing horses.		
Drainage Description	The stream flows north and crosses the public walking trail about midway along its groundtruthed route. From this location water flow is confined to the walking path and continues along this route until close to the main path crossing to the north (1 l/s). The path which the stream flows along is not the lowest route in the vicinity which suggests that the natural drainage route has been blocked or obstructed. The natural flow is more likely to be the steep vegetated valley to the immediate west, or a 4 m deep, north-facing, horseshoe-shaped depression which appears to be a small quarry excavation. Flow from the path enters a small depression immediately upgradient of the main walking trail to the north.		
Proportion Culverted	0%		
Outflow	The stream flows through a stone-built channel recently installed on the lower cliff path before outfalling to the sea through a steep, narrow gorge on a north facing cliff.		
Hydrochemistry			
Issues	Erosion of path and mobilisation of sediment where stream flow is along path surface.		
Measures	Divert stream flow into the narrow valley to the immediate west of the path. Install culvert or raised boardwalk where flow crosses path.		

Site 7 - Whitewater Brook Catchment

Site 7A - Whitewater Brook

Feature Name	Whitewater Brook	Type of Feature	Stream
Survey Date	06/10/20; 08/10/20; 16/10/20	Surveyed by	C. O'Reilly, Envirologic
Centre Coordinates	729,070 / 737,350	Location	Ben of Howth to north of Baily

Bedrock	Cambrian: Mixture (Elsinore); Mudstone/ Greywacke (Gaskins Leap)	Proximity of Structural Fault	Parallel anticline, 250m south
Subsoil	Quartzite till	Soil	Shallow, well-drained acidic mineral
Exposures	Primary exposure on high cliff face at outfall. Bedrock pink/red where fresh collapse. 5 m clay till coverage on bedrock, undermined by recent rock collapse.		



Channel Length	1,000 m	**Catchment to Outfall**	43 ha
Channel Dimensions	Bed width = 0.5 m, bank height = 0.3 m, bank top width = 0.5 m. Bank height increases significantly in the lower catchment.		
Water Levels	109.7 mOD on Tweedy's Lane; 108.2 mOD north of Carrickbrack car park		
Gradient	Upper catchment valley = shallow; Windgate Road-Carrickbrack Road = steep; Carrickbrack Road-Carrickbrack car park = shallow; downgradient of Carrickbrack car park = steep.		
Primary Inflows	Surface runoff from exposed Cambrian bedrock on upper catchment, road runoff, tributary along Tweedy's Lane from Summit tanks.		
Drainage Description	Small dendritic network drains minor valleys on elevated ground which converge to a single inflow at Hilltop House. Between Windgate Road and Carrickbrack Road the stream flows through a grassland field used for grazing horses. This field was not surveyed but it appears the stream is not livestock proofed in this section. Downgradient of Carrickbrack Road the stream enters a natural wet depression and subsequently a small artificial pond. The channel between Carrickbrack car park and the outfall is inaccessible.		
Proportion Culverted	Road crossings only, i.e. negligible.		
Outfall	Steep gorge which terminates in a cascade over coastal cliff immediately north of Dungriffin Promontory to Whitewater Brook Cove. Access to the outfall is possible but difficult.		
Hydrochemistry			
Pressures	Between Windgate Road and Carrickbrack Road significant poaching of stream bed and bank erosion caused by grazing horses. Potential direct defacation from grazing horses. Significant dumping of garden waste in stream on eastern side of Thormanby Road.		
Measures	Restrict animal access from stream as it flows between Windgate Road and Carrickbrack Road. Also check animal access in fields in vicinity of Cabena's Well. Provision of a metered animal drinker if stream is only potable water source for animals. Consider a pilot riparian margin scheme (e.g. wildflower) to protect stream from sediment and nutrient enrichment. Consider improving access path down to beach where Whitewater outfalls. Implement measures to prevent dumping of garden waste.		

Site 7B - Hilltop House

Feature Name	**Hilltop House**	**Type of Feature**	**Artificial pond in wet woodland**
Survey Date	28/09/20; 08/10/20;16/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,824 / 737,427	**Location**	Hilltop House (private property), Windgate Road (see 25" OSI maps)
Area	c. 80m²	**Ground Elevation**	141 mOD

Bedrock	Cambrian: Mixture (Elsinore)	**Proximity of Structural Fault**	Anticline, 750m south
Subsoil	Quartzite till	**Soil**	Peaty
Exposures	Cambrian bedrock on raised ground 250 m northwest		
SW Catchment	Whitewater Brook	**Upgradient catchment**	4.5 ha
Water Levels	c. 141 mOD		
Depth	Estimated 1 - 1.5 m.		
Inflows	Runoff generated in two small raised valleys to the west converge a short distance upgradient of the pond. This flow enters a 150 mm pipe which outfalls to the southwestern end of the pond. Flow estimated on 08/10/20 as 1 l/s.		
Drainage Pattern	Pond appears to have been excavated in a low-lying woodland area as part of a landscaped garden walk. The woodland appears to have been in place for a long time (c.100 years) and there are no contamination sources in the upgradient catchment. On 28/09/20 and 16/10/20 water was confined to the pond. On 08/10/20 and following heavy rainfall water covered much of the low-lying woodland floor.		
Outflows	No level control on pond. A 150 mm PVC pipe installed in berm on western side of Windgate Road releases water that accumulates in the woodland, this subsequently entering a road drainage gully. In this regard the woodland floor provides attenuation storage.		
Hydrochemistry			
Pressures	None in terms of flow or water quality. Invasive species evident. Illegal dumping.		
Measures	Sample water quality entering pond as it is one of the few wetland features with no upgradient pressures. Potential site for the local authority to take in charge; consider protection from future development. Additional measures pending outcome of botanical survey and importance.		

Site 7C - Cabena's Well

Feature Name	**Cabena's Well**	**Type of Feature**	**Shallow Well**
Survey Date	16/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,107 / 737,368	**Location**	Tweedy's Lane, near Summit Stores
Area	1 m²	**Ground Elevation**	112.00 mOD

Bedrock	Cambrian: Mixture (Elsinore)	**Proximity of Structural Fault**	Anticline 500m south
Subsoil	Quartzite till	**Soil**	Shallow, well-drained acidic mineral
Exposures	None. Floor of well chamber may be exposed bedrock.		

SW Catchment	Whitewater Brook	**Upgradient catchment**	n/a
Drainage Pattern	Well is marked on 25" OSI map. Water in the well likely comes from rainfall infiltrating through overburden and flowing on top of the impermeable bedrock.		
Water Level	111.82 mOD		
Depth	200 mm		
Current Inflows	No discrete inflow		
Current Outflows	Outflow to nearby Whitewater Brook, 0.3 l/s.		
Hydrochemistry	C = 392 µS/cm; T = 11.8 °C; pH = 7.3*; ORP = 260 mV; DO = 58%*.		
Pressures	Horses grazing in adjoining field; upgradient construction (e.g. Irish Water compound); future development		
Measures	Raise path here and at nearby stream crossing to prevent mobilised sediment from path entering well chamber. Retrieve sample to establish baseline. Ensure legislative setback being adhered to.		

Site 7D - Carrickbrack Car Park (East)

Feature Name	**Carrickbrack Car Park (East)**	**Type of Feature**	**Artificial Pond**
Survey Date	28/09/20 & 06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,133 / 737,182	**Location**	Between Carrickbrack car park and Thormanby Road
Area	c. 40 m^2 (4 x 10 m oval)	**Ground Elevation**	103.2 mOD

Bedrock	Cambrian: Mixture (Elsinore)	**Proximity of Structural Fault**	350 m south
Subsoil	Quartzite till	**Soil**	Shallow well-drained acidic mineral
Exposures	None		

SW Catchment	Whitewater Brook	**Upgradient catchment**	26 ha
Drainage Pattern	The pond is in-line relative to the Whitewater Brook stream route. A small pedestrian bridge crosses the pond at it's northern end.		
Water Levels	102.96 - 103.01 mOD		
Depth	0.2 m		
Inflows	450 mm concrete culvert beneath Carrickbrack Road, c.10 l/s.		
Outflows	The outflow structure is a 1.2 m wide flat weir, crest 102.96 mOD. Some accumulation of debris on weirtop. 1 m drop over weir. Newly-built stone-arched culvert beneath Thormanby Road: 0.5 m wide, 0.6 m height.		
Hydrochemistry	C = 414 µS/cm; T = 12.5 °C; pH = 7.9*; ORP = 253 mV; DO = 84%*.		
Pressures	Accumulation of debris at outlet which may cause very localised flooding. Car park and road runoff.		
Measures	Install gully or similar to capture stormwater between car park and pond. No real scope to adjust water levels. Include inlet, weir overflows and downstream culvert in regular inspection programme.		

Site 7E - Carrickbrack Car Park (South)

Feature Name	**Carrickbrack Car Park (South)**	**Type of Feature**	**Three artificial ponds**
Survey Date	28/09/20 & 06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	729,109 / 737,077	**Location**	South of Carrickbrack car park
Area	(1) 100 m² (2) 100 m² (3) 250 m²	**Ground Elevation**	94 - 97 mOD

Bedrock	Cambrian: Greywacke (Hippy Hole)	**Proximity of Structural Fault**	300 m south
Subsoil	Quartzite till	**Soil**	Shallow, well-drained acidic mineral
Exposures	None		

SW Catchment	Whitewater Brook (tributary)	**Upgradient catchment**	3 ha
Drainage Pattern	Three ponds arranged in sequence with interconnecting weirs, fed by a small catchment on the western side of the Carrickbrack Road, possibly road runoff.		
Water Levels	(1) 96.60 mOD (2) 95.42 mOD (3) 94.13 mOD		
Depth	(1) 0.4 m (2) 0.3 m (3) 0.5 m		
Inflows	Box culvert beneath Carrickbrack Road, width 0.6 m, height 1 m, flow 2 l/s.		
Outflows	Flat top weirs form the outfall from each pond, which cascades directly into the subsequent pond. Outfall from Pond 3 is a 200 mm PVC pipe, which is culverted beneath Thormanby Road and subsequently enters the main channel of the Whitewater Brook.		
Hydrochemistry	C = 469 µS/cm; T = 12.6 °C; pH = 7.7*; ORP = 285 mV; DO = 79%*.		
Pressures	Growth of surface algae suggests nutrient inputs.		
Measures	Catchment survey and water quality testing to determine source of nutrient enrichment. No scope to adjust water levels. Include inlets and weir overflows on all ponds in regular inspection programme to ensure structures are free of heavy vegetation or other potential blockages. Consider dredging of Pond 1. Remove fallen trees from Pond 3.		

Site 8 - Balsaggart Stream Catchment

Site 8A - Balsaggart Stream

Feature Name	**Balsaggart Stream**	**Type of Feature**	**Stream**
Survey Date	06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,725 / 736,988	**Location**	Southern slope of peninsula
Bedrock	Upper catchment - Mixed Cambrian (Elsinore) Mid-catchment - Greywacke/bentonite (Hippy Hole) Lower catchment - Quartzite/mudstone (Drumleck)	**Proximity of Structural Fault**	750 m northwest
Subsoil	Quartzite till	**Soil**	Deep/shallow, well-drained acidic mineral
Exposures	Bedrock fully exposed on higher ground. Relatively fresh exposure in lower catchment, possibly legacy of localised quarrying.		

Channel Length	1,000 m	**Catchment to Outfall**	91 ha

Channel Dimensions	For reference the upper catchment refers to raised grounds north of Carrickbrack Road; the mid-catchment refers to farmlands; the lower catchment refers to lands between the farmed area and the outfall. Lands in the mid and lower catchments are referred to as 'The Cliffs'. Upper catchment: narrow, steep natural mountain stream with bedrock bed. Bed width 0.3 m, bank height 0.2 m. Mid catchment: flat to moderate, open channel with silty, weedy bed. Bed width 1 m, bank height 1.5 m, bank top width 3 m. Lower catchment: constructed channel 0.5 m wide base, 0.4 m high side walls, gravel bed, flow 15 l/s. Changes to a natural channel with heavy scrub on approach to outfall.
Surveyed Water Levels	Upper catchment = 110 - 121 mOD Mid-catchment = 36 - 42 mOD Lower catchment = 7.6 - 34 mOD
Gradient	Low (mid-catchment) to steep (upper catchment)
Primary Inflows	Runoff from raised ground, Howth Golf Club Reservoir, road runoff, farmland runoff and subsurface drainage.
Drainage Description	The headwaters of the stream are formed in the eastern side of Howth Golf Club where runoff generated on raised ground to the east converges to a single rocky channel at the southeastern corner of the course, leaving via a short 300 mm concrete piped culvert. Between the golf course and the Carrickbrack Road streamflow is within a steep, open channel with a rocky bed and mostly inaccessible due to scrub encroachment. The channel is culverted between houses on the northern side of Carrickbrack before flowing through grassland fields used for grazing horses on the southern side. The stream dimensions become wider as the hydraulic gradient flattens out approaching the northern foot of an east-west raised ridge. The stream then flows east alongside an internal access road and cascades over a 400 mm wide weirtop in a stone wall before turning south. Localised flooding has reportedly occurred previously in this area. The stream continues southwards along the eastern side of a private laneway in a constructed channel before flowing through a grassland pasture. A spring seep in this area is apparent due to wet grassland though this appears to be shallow groundwater accumulating on the upgradient side of a boundary wall. A small well was observed in the front garden of the 'Well House' on the southern side of Carrickbrack Road. This appears in an exposed section of surface or shallow groundwater flow which is subsequently piped southwards to the Balsaggart Stream. Downgradient of the cascade feature a relatively fresh 4 m high vertical bedrock exposure is present on the western side of the laneway. This formed part of a continuous east-west raised ridge which runs between The Cliffs and Tansey House. It is possible that this short section was excavated to provide access to lands to the south, while also providing stone for construction. Historical maps confirm quarrying took place at this location. Immediately upgradient and trending west of this exposure is a dry valley feature, currently natural woodland, potentially the original Balsaggart Stream route. This theory is reinforced by the unnatural hydromophology of the current stream route downgradient of this area. The dry valley may be a glacial feature, with a more natural outfall landscape evident along the coast 300 m northwest of the current outfall, where relatively low flow of surface water (1.5 l/s) was noted.
Proportion Culverted	5%
Outfall	The stream is bridged over a public walking trail and subsequently outfalls to the sea over a rocky shore, referred to in 'Rivers of Dublin' as 'Sheep's Hole'.
Hydrochemistry	
Issues	
Measures	Further investigation into the dry valley glacial feature south of farmed grassland. Follow up botanical survey on dry (possibly glacial) valley which runs east-west just north of the ornamental ponds. There is some evidence that this may have been the original, natural route of Balsaggart Stream. Consider clearing scrub on stream though this may not be a worthwhile/sustainable measure given it will revert rapidly. Need an alternative stream bank vegetation approach. The channel to Doldrum Bay was not included but there have been ongoing complaints of an untreated sewage outfall. It is understood that remedial works are planned.

Site 8B - Howth Golf Club Reservoir

Feature Name	**Howth Golf Club Reservoir**	**Type of Feature**	**Constructed Pond**
Survey Date	06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,030 / 737,431	**Location**	Eastern area of Howth Golf Club
Area	1,200 m^2	**Ground Elevation**	123 mOD
Bedrock	Mixed Cambrian (Elsinore)	**Proximity of Structural Fault**	500 m northwest
Subsoil	Lacustrine sediments	**Soil**	Shallow, well-drained acidic mineral
Exposures	Surrounding raised ground		
SW Catchment	Balsaggart	**Upgradient catchment**	29 ha
Water Levels	122.23 mOD		
Depth	Up to 4 m in centre		
Inflows	Runoff and subsurface drainage network. The pond is topped up with groundwater from an adjacent 40 m deep well. The well was installed in recent years to replace a previous 4 m deep shallow well.		
Drainage Pattern	The pond is sited within the base of a large natural depression. This area was described in historical literature as the central marsh and is labelled on the 6" OSI maps as 'Site of Lough'. A separate reference makes mention of the second nine holes at Howth Golf Club being in an area known as the 'Bay of Loughs'.		
Outflows	The pond is used as a source of irrigation for the course. Only tees and greens are irrigated and these only through spring and summer months (last irrigation of 2020 was mid-September). Well yield is reportedly in the order of 312 m^3/d which would be considered very good for this bedrock formation. The pond reportedly doesn't have a discrete piped outflow to control maximum level with water instead dissipating through banked side walls. It is unclear relationship between pond water level and non-pumping groundwater level.		
Hydrochemistry			
Pressures	Adjacent toilet served by a Bicycle wastewater treatment system with treated effluent discharged to an adjacent percolation area. This toilet is not used frequently.		
Measures	Contributing catchment require further clarification. Confirm catchments to inflows via more detailed walkover survey of drainage network. Consider commissioning a small project to assist groundsmen at Howth Golf Club in the development of a current drainage map. Discuss and review groundwater pumping regime with HGC. There is a need to ascertain potential for excessive dewatering at this location. Review of the abstraction regime may result in cost savings to operator. Consider long-term water level monitoring in pond. Sample stream downgradient of reservoir to assign baseline water quality conditions. Include parameters to assess use of fertiliser, pesticide, herbicide. Also bacteria to measure efficacy of Biocycle and percolation area on inner course toilet. HGC may be receptive to liaising with local authority for assistance in developing/supporting enhanced biodiversity areas at suitable locations on the course.		

Site 8C - Kings Tank

Feature Name	**Kings Tank**	**Type of Feature**	**Constructed Reservoir**
Survey Date	06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	728,061 / 737,126	**Location**	Carrickbrack, 300 m north of Carrickbrack Road
Area	250 m^2	**Ground Elevation**	Tank perimeter = 136 mOD Tank base = 129 mOD

Bedrock	Cambrian: Quartzite (Elsinore)	**Proximity of Structural Fault**	1 km northwest
Subsoil	None	**Soil**	Shallow acidic podzol (peaty) topsoil
Exposures	Quartzite exposed across area		
SW Catchment	Balsaggart	**Upgradient catchment**	0.3 ha
Water Levels	Appears dry but floor inaccessible unconfirmed.		
Depth	7 m below surrounding bedrock ridge		
Inflows	Small raised bedrock valley which extends 75 - 100 m east. Rainfall on surrounding impermeable bedrock collected in narrow valley channel and flows westwards into 'tank'.		
Drainage Pattern	King's Tank is shown on all historical maps and is assumed to have been developed to collect and store potable water for local residents/farms. The tank base is approximately 7 m below the surrounding bedrock plateau. The western end of the valley appears to have deepened by excavation and a 7 m high concrete wall cast to impound water. The eastern side of the excavation is steep and has been reinforced in places with dry stone walling. Water collected in a narrow valley channel to the east enters the eastern side of the excavation.		
Outflows	Flow/level control sluice valve at the base of the dam wall.		
Hydrochemistry			
Issues			
Measures	Conduct botanical survey on tank floor. Explore feasibility of raising outlet of King's Tank to impound a small amount of water. May not be sensible given there is a new residence immediately downgradient of dam wall. Preserve as evidence of local water engineering heritage.		

Site 8D - Balsaggart Well

Feature Name	**Balsaggart Well**	**Type of Feature**	**Shallow Well**
Survey Date	16/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,770 / 736,966	**Location**	Close to Balsaggart Stream crossing under Carrickbrack Road
Area	N/a	**Ground Elevation**	c. 65 mOD

Bedrock	Cambrian greywacke (Hippy Hole)	**Proximity of Structural Fault**	1 km northwest
Subsoil	Quartzite till	**Soil**	Shallow, well-drained acidic mineral
Exposures	Cambrian bedrock exposed on raised ground and stream bed to north.		
SW Catchment	Balsaggart Well	**Upgradient catchment**	Extends 500 - 800 m north towards Kings Tank.
Drainage Pattern	The well chamber is clearly marked by a gothic shaped arch in the stone wall. The well chamber has been blocked up with stone on various occasions. It is unclear if the chamber remains in situ behind the stone wall. Cement grout around the lower stones has been eroded away, possibly by groundwater discharge and many of the stones are loosely resting in place.		
Water Levels	Inaccessible		
Depth	n/a		
Inflows	Water in the well likely comes from rainfall infiltrating through overburden and flowing on top of the impermeable bedrock.		
Outflows	Water emerging from behind stone wall and draining to road gulley suggests flow path still active.		
Hydrochemistry	n/a		
Issues	Well chamber opening has been closed with constructed stone wall.		
Measures	Worthy of further discussion from a heritage perspective but not of ecological importance.		

Site 8E - 'The Cliffs' Farm

Feature Name	**'The Cliffs' Farmland**	**Type of Feature**	**Agricultural grasslands**
Survey Date	06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	Wetland: 727,558 / 736,874 Ponding behind hayshed: 727,334/737,009 Rushes nr Well House: 727,748 / 736,904	**Location**	Southern side of Carrickbrack Road
Area	Wetland and rushy area	**Ground Elevation**	37 - 60 mOD
			
Bedrock	Cambrian: Quartzite/mudstone (Drumleck)	**Proximity of Structural Fault**	150 m northwest
Subsoil	Quartzite till	**Soil**	Deep, well-drained acidic mineral
Exposures	Raised ridge to southwest, between fields and coast		
SW Catchment	Balsaggart	**Upgradient catchment**	84 ha
Water Levels	35.2 (base of cascade) - 42.42 mOD (stream 100 m downgradient of Carrickbrack Road); Wetland = 38.36 mOD Ponding to rear of hayshed = 40.99 mOD		
Depth	Wetland = c. 1.5 m Ponding to rear of hayshed = 100 mm		
Inflows	The primary inflow to the farm area is the Balsaggart Stream.		
Drainage Pattern	Drainage on the farm was upgraded approximately 20 years ago and involved drain cleaning, culvert and headwall installation. A short, minor west-east dry valley falls through public lands to the rear (western end) of the farmyard. At this location there is a small topographical depression which contains ponded water for much of the year. This water is assumed to enter a culvert which runs west-east beneath the farmyard (unconfirmed) before outfalling to an open drain which reaches the entrance laneway. A separate parallel open drain flows in an easterly direction, setback 70 m north of the farmyard, reaching the farm entrance laneway before turning south. These drains converge at the southern end of the entrance laneway and outfall to the Balsaggart Stream 250 m further east. On the eastern side of the entrance laneway a separate open field drain is in continuity with a 1,200 m^2 D-shaped wetland area which contains a small island. The feature is indicated on historical maps. Water level in the wetland was recorded as 38.36 mOD; ground level around the wetland is 39.0 mOD. Some ponding was noted on grassland south of this wetland, likely a result of deposition of low permeability subsoil some years ago. An enclosure around a borehole was observed south of the southern end of the farm entrance laneway; this well is understood to serve a third party private residence.		
Outflows	The stream leaves what is considered to be the farm area at the aforementioned cascade.		
Hydrochemistry			

Pressures	To the south of 'Well House' are an abundance of rushes, some in a linear pattern. Some diffuse upwelling of water, ponded areas and very slight foul smell. This was attributed to possible disturbance of a historical percolation area during deep ploughing approximately 20 years ago. Water appears to infiltrate again to ground some 30 m downgradient of the linear belt of rushes. Poaching, bank erosion and defacation from horses using the stream as a drinking water source. Farmyard runoff or washing out of stables. It is assumed that there is little or no fertiliser used on the pastures.
Measures	Consider small walkover survey and door-to-door discussions to ascertain source of ponding and malodour southwest of Well House. Surface water sampling on stream upgradient and downgradient of farm to identify contaminants. Potential sample points include road crossing and cascade at southern end of laneway junction at eastern end of farm. Consider clearance of scrub around farm wetland to provide better access for surveying. Survey size and levels of wetland island. Botanical survey of central wetland area and island. Restrict animal access to stream for drinking. Facilitate installation of animal drinkers.

Site 8F - The Cliffs Ornamental Ponds

Feature Name	**'The Cliffs' Onamental Ponds**	**Type of Feature**	**Constructed Ponds**
Survey Date	06/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,727 / 736,499	**Location**	Adjacent to internal access road
Area	3 ponds, each c. 7 m^2	**Ground Elevation**	c. 25 mOD
			
Bedrock	Cambrian:	**Proximity of Structural Fault**	1 km northwest
Subsoil	Quartzite till	**Soil**	Deep, well-drained acidic mineral
Exposures	Fresh outcrop immediate northwest.		
SW Catchment	Balsaggart	**Upgradient catchment**	84 ha
Water Levels	c. 25 mOD		
Depth	300 mm		
Inflows	Overflow from Balsaggart stream via 40 mm PVC pipe.		
Drainage Pattern	Interconnected arrangement of three small ponds (c. 7 m^2 each). A small concrete chamber between the ponds and the stream is reportedly an old groundwater spring chamber. If the dry valley feature described above carried the primary stream flow, it may be that this groundwater spring was the original source of flow in the small channel downstream of this point.		
Outflows	Final outflow returns water to Balsaggart Stream.		
Hydrochemistry			
Issues	Unclear how regularly stream levels are high enough to activate the inflow pipe.		
Measures	If the ecologist deems beneficial pond water levels can be easily manipulated by adjusting the levels of the inflow, outflow and connecting pipes.		

Site 9 - Carrickbrack Stream Catchment

Site 9A - Carrickbrack Stream

Feature Name	**Carrickbrack Stream**	**Type of Feature**	**Stream**
Survey Date	29/01/21	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,482 / 738,153	**Location**	Howth Golf Club / Deerpark Golf Course

Bedrock	Cambrian Quartzite & mudstone (Drumleck)	**Proximity of Structural Fault**	Southwest-northeast crosses catchment
Subsoil	Quartzite till	**Soil**	Shallow well-drained acidic mineral
Exposures	Southern and western faces of Dun Hill; northern and eastern faces of Shielmartin		
Channel Length	2,250 m	**Catchment to Outfall**	98 ha
Channel Dimensions	Upper catchment drained by open arterial drainage channels on northern and southern perimeter of HGC (western area), these are up to 1 m deep. Middle catchment drained by open channels through wooded areas on Deerpark Golf Course. Lower catchment west of Carrickbrack Road drained by stormwater network.		
Water Levels	Typically 1 m below ground level in open channels.		
Gradient	Moderate through HGC, steepening through the wooded area between HGC and Deerpark. Gradient flattens out through much of Deerpark and alongside Howth Celtic soccer pitch.		
Primary Inflows	Diffuse flows from upper catchment, rainfall-runoff generated on hardstanding in lower catchments.		
Drainage Description	Fed by diffuse runoff from Dun Hill and Shielmartin which is collected in open arterial drains. These channels flow through a steep wooded area where channels are unmaintained. Through Deerpark there is a mixture of open channels through wooded areas and subsurface culverts crossing fairways. Waters enter stormwater network upon meeting Carrickbrack Road.		
Proportion Culverted	30%, mostly below Carrickbrack Road.		
Outfall	Coastline along Strand Road		
Pressures	Arterial drainage. Future development in Deerpark estate is likely to alter current drainage regime.		
Measures	Regular inspection of stream banks to ensure structural stability. Consider commissioning a small project to assist groundsmen at Howth Demesne to develop a current drainage map.		

Site 9A - Wet Area West of Dun Hill

Feature Name	**Wet Area West of Dun Hill**	**Type of Feature**	**Wet Area**
Survey Date	29/01/21	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,723 / 737,890	**Location**	25 m south of eastern end of right-of-way across Howth Golf Club
Area	c. 10 m^2	**Ground Elevation**	c. 110 mOD
Bedrock	Cambrian Quartzite & mudstone (Drumleck)	**Proximity of Structural Fault**	Southwest-northeast mapped through site
Subsoil	Quartzite till	**Soil**	Shallow well-drained acidic mineral
Exposures	Steep quartzite escarpment on western side of Dun Hill 20 m to east.		
SW Catchment	Headwaters of Carrickbrack Stream	**Upgradient catchment**	Extends 300 m southeast
Drainage Pattern	Surface water draining of western face of Dun Hill collects in a minor raised valley which directs water northwest towards wooded area. One metre deep open arterial drainage channels serving the northern perimeter of Howth Golf Club may accelerate drainage in this area.		
Water Levels	Minor ponding at surface. No clear evidence of linear flow but area obscured by heavy vegetation.		
Depth	n/a		
Inflows	Diffuse		
Outflows	Drainage towards channel that continues northwest through wooded area.		
Hydrochemistry			
Issues	Arterial drainage serving northern perimeter of Howth Golf Club may accelerate drainage and has potential to lower water table. Pre-arterial drainage regime unknown.		
Measures	Consider clearance of vegetation and aerial topographical survey to identify any natural enclosed topographical depressions or linear channels. Consider rerouting of drainage channel on left of 3rd fairway (after dog-leg) to re-wet area at foot of Dun Hill.		

Site 9B - St. Fintan's Well

Feature Name	**St. Fintan's Well**	**Type of Feature**	**Shallow Well**
Survey Date	28/09/20 & 16/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,078 / 737,797	**Location**	Opposite entrance to Howth Golf Club
Area	0.5 m^2	**Ground Elevation**	c. 55 mOD
			
Bedrock	Cambrian Quartzite & mudstone (Drumleck)	**Proximity of Structural Fault**	Parallel southwest-northeast faults mapped 250 m to the northwest and southeast
Subsoil	Limestone till	**Soil**	Shallow well-drained acidic mineral
Exposures	Steep quartzite escarpment 200 m north. This is assumed to be the correct line of faulting that separates the Carboniferous and Cambrian.		
SW Catchment	Direct to coast (included in Carrickbrack catchment for purposes of grouping field sheets),	**Upgradient catchment**	Extends 500 m east to peak of Shielmartin
Drainage Pattern	Spring well located on the fault line that separates the older Cambrian metasediments from the more recent limestones.		
Water Levels	dry		
Depth	n/a		
Inflows	none		
Outflows	Well is dry. The previous outfall entered a channel which flowed north to rear of old graveyard. This channel terminates at the northeastern corner of Sutton Park all-weather hockey pitch. Presumably it flowed west along rear of newer graveyard through a culvert or open channel, outfalling in the vicinity of Sutton Dinghy Club.		
Hydrochemistry	dry		
Issues	The reason for the well drying up is unconfirmed. Primary contributing factors are likely to have been mains stormwater network along road and construction of dwelling directly downgradient (west). Subsurface foundations and/or basement construction may have disrupted groundwater flow paths. Infilling of a small valley area upgradient to facilitate a car park is also a potential factor. Landscaping around the site would suggest that the well is within the front garden of a private residence.		
Measures	It is not possible to remediate the damage to the hydrogeological regime supplying the well. The well structure should be preserved.		

Site 10 - Santa Sabina Stream Catchment

Site 10A - Offington Wetland

Feature Name	**Offington Wetland**	**Type of Feature**	**Constructed Wetland**
Survey Date	05/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727,000 / 738,872	**Location**	Western edge of Howth Demesne, rear of Offington Lawn
Area	North Pond = 2,620 m² South Pond = 2,280 m²	**Ground Elevation**	Surrounding ground = 17.0 - 18.4 mOD Northern pond base = 15.42 - 15.70 mOD Southern pond base = 16.25 - 16.55 mOD

Bedrock	Waulsortian limestone	**Proximity of Structural Fault**	250 m east (Cambrian)
Subsoil	Limestone till	**Soil**	Deep, well-drained basic mineral
Exposures	None nearby		

SW Catchment	Mains stormwater network	**Upgradient catchment**	Estimated 10 ha (combined) to the east and within Deerpark Golf Course
Historical Drainage Pattern	Cassini maps show a convergence of drainage channels at this location though flow directions and connectivity of same are unclear. The ponds were installed 20-30 years ago to restrict people freely entering the golf course from Offington Lawn residential area. The ponds subsequently and inadvertently attracted young children as a play area. Resulting from this, combined with health and safety concerns, the pond inlet and outlet levels were adjusted to ensure submerged depth was never greater than 300 mm. The ponds are unlined so there is some uncertainty around their ability to retain water across the entire base.		
Water Levels	Northern pond = 15.55 - 15.72 mOD (sloping south to north) Southern pond = 16.17 - 16.55 mOD (sloping north to south)		
Water Depth	Northern pond = 90 - 180 mm Southern pond = 60 - 230 mm		
Current Inflows	Northern pond: Single discrete inflow from a 225 mm concrete pipe (IL = 15.98 mOD) on the eastern edge of the northern pond. This pipe is an outfall from the subsurface drainage network. Flow emanating from this pipe was estimated as 1.5 l/s (heavy rainfall preceding 3 days). Assumed zero inflow during prolonged dry weather. The ponds are separated by a raised embankment (bank top = 16.75 - 18.1 mOD). Southern pond: Not clearly identified but southward flow observed through a lowered point at the eastern end of the embankment. Aerial photography suggests a linear subsurface drain outfalls to this point. The southern pond seems to have had some infilling on the eastern side which is raised relative to the western half.		
Current Drainage Pattern	It initially appeared during survey that flow from the northern pond inlet travelled south through the northern pond, across an overflow in the embankment, through the southern pond towards an outflow at its southern end. However, surveyed levels suggest that the ponds may not be connected and that the lowered eastern end of the embankment facilitates a separate inflow. Hence it seems more plausible each pond has its own independent inflow and outflow. Local stormwater network map would help to confirm this.		
Current Outflows	Water levels in the northern pond suggest an outflow at the northwestern corner though this was not observed. Outflow from southern pond is presumed to be at the base of a concrete wall abutting the southwest corner, though the outlet itself was not observed (assumed at the time to be submerged). Alterations to golf course drainage (subsurface and surface channels) and alterations of local mains stormwater network, including recent Offington flood alleviation scheme make it difficult to confirm catchments, inflow and outflow routes.		

Pressures	Lack of knowledge around variation in winter/summer hydrological regime. Disruption to contributing catchment and water quality as a result of likely future development works.
Measures	Inflow and outflow locations require further clarification. Remove vegetation around inlets and outlets. Reveal and clean outlet structure(s) of any blockages. Confirm any other drainage inflows. Contributing catchments require further clarification. Confirm catchments to inflows via more detailed walkover survey of Deer Park drainage network. Sample inflow water quality to assign baseline conditions. Include parameters to assess use of fertiliser, pesticide, herbicide. Discuss recommended protocol for use of same with groundsman. Consider this approach also with groundsmen at Sutton GC and Howth GC. All groundsmen encountered were open to liaising with local authority for assistance to develop/support enhanced biodiversity areas on their courses. Ecologist to decide on a target water depth for northern pond. Grade pond base and adjust inlet and outlet inverts accordingly, if possible/required. Investigate consequence of outlet becoming blocked (may require a relief overflow to stormwater network). Include inspection of inlet and outlet as part of inspection programme. Provide statutory protective measures as catchment/drainage infrastructure/pond layout may be manipulated as part of future development works which would disrupt regime. Consider flow and level monitoring for minimum one year to assist understanding of winter/summer flow regimes and minimum and maximum water depths.

Site 11 - Sutton Golf Club Ponds

Site 11A - Pond A

Feature Name	**Sutton Golf Club Pond A**	**Type of Feature**	**Artificial Pond**
Survey Date	14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	725,582 / 739,767	**Location**	Northern course, east of entrance barrier
Area	460 m²	**Ground Elevation**	3 mOD

Bedrock	Limestone/Shale (Tober Colleen)	**Proximity of Structural Fault**	1 km southeast
Subsoil	Windblown sands and dunes	**Soil**	Windblown sediments
Exposures	Dunes viewed from Burrow beach		
SW Catchment	n/a (coastal)	**Upgradient catchment**	N/a
Water Levels	1.23 mOD		
Depth	c. 1 m		
Inflows	Surrounding subsurface drainage network. Groundwater.		
Drainage Pattern	Previously used as an irrigation supply, this practice ceased due to the small pond size and susceptibility to saline intrusion.		
Outflows	Equilibrium with groundwater. In the case of high water levels excess water is pumped to the western estuary.		
Hydrochemistry	C = 528 µS/cm; T = 11.7 °C; pH = 7.8*; ORP = 277 mV; DO = 72%*.		
Issues	None		
Measures	None		

Site 11B - Pond B

Feature Name	**Sutton Golf Club Pond B**	**Type of Feature**	**Artificial Pond**
Survey Date	14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	725741 / 739667	**Location**	Northern course, midway southern boundary
Area	3,000 m^2	**Ground Elevation**	1.5 mOD

Bedrock	Limestone/Shale (Tober Colleen)	**Proximity of Structural Fault**	1 km southeast
Subsoil	Marine beach sands / till	**Soil**	Windblown sediments
Exposures	Dunes viewed from Burrow beach		

SW Catchment	n/a (coastal)	**Upgradient catchment**	
Water Levels	1.34 mOD		
Depth	2.5 - 3 m		
Inflows	Surrounding subsurface drainage network. Groundwater flow from south.		
Drainage Pattern	Used as primary irrigation supply for northern course during prolonged dry weather. In the case of high water levels excess water is pumped to the western estuary.		
Outflows	In the case of water levels rising to inundate surrounding fairways excess water is pumped to the western estuary. Maximum drawdown during pumping is 1.8 m to ensure pond does not dry out.		
Hydrochemistry			
Issues	Finite volume as an irrigation supply. Minimum pond water depth of 1.0 m maintained to prevent pond substrate drying out. When water levels approach minimum depth irrigation is restricted to tees and greens. Liquid seaweed fertiliser is used, 2 m buffer applied to ponds. Weedkiller used sparingly, 2 m buffer applied to ponds. Some algal bloom can occur during warm, dry conditions which suggest nutrient input. Algacide used sparingly. Previous attempts to source groundwater irrigation supply from bedrock aquifer proved unsuccessful. Reportedly moderate-high yielding well < 500 m from golf course abstracting from Waulsortian limestones.		
Measures	Consider sluice-controlled gravity-fed pipe to release excess water to sea. The sluice could be automated to function only when tidal levels permit.		

Site 11C - Pond C

Feature Name	**Sutton Golf Club Pond C**	**Type of Feature**	**Artificial Pond**
Survey Date	14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	725,888 / 739,538	**Location**	Southern course, eastern of 3 ponds
Area	1,400 m^2	**Ground Elevation**	2.5 mOD

Bedrock	Limestone/Shale (Tober Colleen)	**Proximity of Structural Fault**	800m southeast
Subsoil	Marine beach sands / till	**Soil**	Windblown sediments
Exposures	Dunes viewed from Burrow beach		

SW Catchment	n/a (coastal)	**Upgradient catchment**	
Water Levels	1.27 mOD		
Depth	Estimated 2 m		
Inflows	Surrounding subsurface drainage network. Groundwater.		
Drainage Pattern	Ponds C, D and E are aligned along the route of a historical drainage channel shown on 25" OSI maps. Pond C and Pond D are connected via a subsurface pipe installed 2 m below the intervening green. A recently installed concrete channel at the eastern end of Pond C becomes active when pond water levels exceed 1.26 mOD. A 30 mm pipe (IL = 1.37 mOD) at the southeastern end of the channel acts as an overflow outlet. This reportedly transmits excess water to a flood relief pipe recently installed by the local authority along the right of way south of the ponds. Pond C was emptied and cleaned to facilitate installation of the flood relief channel. While empty groundwater inflow was observed as spring seeps emanating between till and sand lenses exposed on the southern bank. Eels have been observed in Ponds C, D and E.		
Outflows	Concrete channel		
Hydrochemistry	C = 627 µS/cm; T = 12.9 °C; pH = 8.0*; ORP = 270 mV; DO = 67%*.		
Issues	None		
Measures	None		

Site 11D - Pond D

Feature Name	**Sutton Golf Club Pond D**	**Type of Feature**	**Artificial Pond**
Survey Date	14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	725,784 / 739,528	**Location**	Southern course, central of 3 ponds
Area	1,100 m^2	**Ground Elevation**	2.5 mOD

Bedrock	Limestone/Shale (Tober Colleen)	**Proximity of Structural Fault**	800 m southeast
Subsoil	Marine beach sands / till	**Soil**	Windblown sediments
Exposures	Dunes viewed from Burrow beach		

SW Catchment	n/a (coastal)	**Upgradient catchment**	
Water Levels	1.27 mOD		
Depth	Estimated 2 m.		
Inflows	Surrounding subsurface drainage network. Groundwater.		
Drainage Pattern	As per Pond C, facilitated by subsurface connector pipe		
Outflows	As per Pond C.		
Hydrochemistry	C = 824 µS/cm; T = 12.4 °C; pH = 8.2*; ORP = 284 mV; DO = 78%*.		
Issues	Water contained in Pond D reportedly went a blood red colour on one occasion in recent years with malodour detected. Source of the colour suggests presence of metals in the area which may have precipitated out of solution upon recent oxidisation. Literature makes reference to a midden (ancient rubbish dump) at Sutton and construction of a recent flood relief pipe may have disturbed content. though any connection between the two is merely hypothesis.		
Measures	Surface water quality monitoring.		

Site 11E - Pond E

Feature Name	**Sutton Golf Club Pond E**	**Type of Feature**	**Artificial Pond**
Survey Date	14/10/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	725,666 / 739,517	**Location**	Western of 3 ponds
Area	535 m²	**Ground Elevation**	2.5 mOD.

Bedrock	Limestone/Shale (Tober Colleen)	**Proximity of Structural Fault**	800 m southeast
Subsoil	Marine beach sands / till	**Soil**	Windblown sediments
Exposures	Dunes viewed from Burrow beach		
SW Catchment	n/a (coastal)	**Upgradient catchment**	
Water Levels	1.22 mOD		
Depth	Estimated 2 m		
Inflows	Surrounding subsurface drainage network. Groundwater. Estuarine waters observed entering the pond via 300 mm pipe.		
Drainage Pattern	Conductivity levels clearly show that the westernmost pond is in continuity with saline waters. A 300 mm pipe at the eastern end of this pond provides direct connectivity with the estuary to the west. A sluice flap is in place at the pipe outlet but may have failed. This pond reportedly contains mullet which heron have been seen feeding on.		
Outflows	Estuarine pipe		
Hydrochemistry	C = 25,149 µS/cm; T = 12.4 °C; pH = 8.3*; ORP = 251 mV; DO = 110%*.		
Issues	Inflow of estuarine waters on a rising tide. The different hydrochemistry in this pond relative to the interconnected Ponds C and E provides a unique habitat. Currently there are no plans to repair the sluice flap.		
Measures	None.		

Site 12 - Howth Castle Streams Catchment

Site 12A - Swan Pond

Feature Name	**Swan Pond**	**Type of Feature**	**Artificial Pond**
Survey Date	28/09/20	**Surveyed by**	C. O'Reilly, Envirologic
Centre Coordinates	727686 / 739001	**Location**	Rear of Howth Castle
Area	1,750 m^2	**Ground Elevation**	20 mOD

Bedrock	Impure limestone (Ballysteen)	**Proximity of Structural Fault**	200 m south (Cambrian/Limestone)
Subsoil	Limestone till	**Soil**	Deep, well-drained basic mineral
Exposures	Not in immediate vicinity		
SW Catchment	Coastal	**Upgradient catchment**	8.5 ha
Water Levels	19.56		
Depth	c. 1 m		
Inflows	Inflow from subsurface drainage network serving part of Deer Park Golf Course directly south.		
Drainage Pattern	Relatively small and shallow pond with a constructed perimeter. Clearly indicated on all historical maps.		
Outflows	Assumed to be culvert beneath Transport Museum before outfalling to Claremont Beach close to County Council depot at Baltray.		
Hydrochemistry			
Issues	None known		
Measures	Preserve in current format. Any future development works in area likely to disrupt drainage inflow catchment and outflow route.		