The Geological Heritage of South Dublin County

An audit of County Geological Sites in South Dublin County

by Ronan Hennessy, Robert Meehan, Matthew Parkes, Vincent Gallagher and Sarah Gatley

2014

An Chomhairle Oidhreachta
The Heritage Council

Comhairle Contae
Átha Cliath Theas
South Dublin County Council

GSI
Suirbhéireacht Gheolaíochta Éireann
Geological Survey of Ireland

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The South Dublin County Geological Heritage Project was supported by

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This report is an action of the South Dublin County Heritage Plan 2010 – 2015

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Site Name
Not represented in South Dublin County

Report Summary

South Dublin County is not widely known for its geological heritage, yet it has some very fine but underappreciated geological sites. The County Council's support for this audit is critical in raising the profile of geological heritage in South Dublin County and for maximising its potential, since some of the sites may be overlooked in comparison to the greater wealth of sites in neighbouring counties such as Wicklow.

This report documents what are currently understood by the Irish Geological Heritage Programme (IGH) of the Geological Survey of Ireland (GSI) to be the most important geological sites within South Dublin County. It proposes them as County Geological Sites (CGS), for inclusion within the South Dublin County Development Plan (CDP). The audit provides a reliable study of sites to replace a provisional listing based on desk study which was adopted in a previous CDP.

County Geological Sites do not receive statutory protection like Natural Heritage Areas (NHA) but receive an effective protection from their inclusion in the planning system. However, none of the sites described in this report are considered to be of national importance as best representative examples of particular geological formations or features. If they were they could be notified to the National Parks and Wildlife Service (NPWS) by the GSI for designation as Natural Heritage Areas (NHAs) after due survey and consultation with landowners. In other counties, many of the sites fall within existing pNHAs and SACs where the ecological interest is actually founded upon the underlying geodiversity. In South Dublin County, because it is very urban, only Kippure and part of the Brittas Gravel Complex are coincident with biodiversity designations. However other sites such as the Dodder Terraces and the Lucan Esker are also valuable wildlife and amenity greenspaces within urban settings.

The commission of this audit and adoption of the sites within the County Development Plan ensure that South Dublin County follows a now established and effective methodology for ensuring that geological heritage is not overlooked in the general absence of allocated resources for progress at national level. It ensures that South Dublin County remains at the forefront of geological conservation in Ireland.

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This report is written in non-technical language (with a glossary for unavoidable geological terminology) as a working document for use by the Heritage Officer and the Planning department of South Dublin County Council. It should also be made available via the County Council website for the people of South Dublin County. A chapter of the report includes recommendations on how to best present and promote the geological heritage of South Dublin County to the people of the county. It will also inform the work of the IGH Programme and be made available through the GSI website.

The preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column particularly may be used as they stand to preface a booklet or as website information in the development of this work, and for information, as seen fit by the Heritage Officer. The contents also provide the essential ingredients for a public-oriented book or other publications on the geological heritage of South Dublin County, if the funding can be found to produce them.

South Dublin County in the context of Irish Geological Heritage

This report ensures South Dublin County remains active at the forefront of geological heritage within Ireland, as more than half of the counties have now commissioned such an audit within the scope of the county-based Heritage Plan. It will hopefully encourage the remaining local authorities to follow what is now a tried and trusted methodology. In the absence of significant political and economic resources available at a national level to the relevant bodies for conservation of geological heritage as Natural Heritage Areas (NHA), it represents a significant level of progress in defining and safeguarding Ireland's geological heritage.

It also represents a significant commitment on the part of the Local Authority to fulfil its obligations to incorporate geology into the spectrum of responsibilities under the Heritage Act 1995, the Planning and Development Act 2000, Planning and Development Regulations 2001, and the Wildlife (Amendment) Act 2000 and the National Heritage Plan (2002). GSI views partnerships with the local authorities, exemplified by this report, as a very important element of its strategy on geological heritage (see Appendix 1).

The Irish Geological Heritage Programme (IGH) in GSI complements other nature conservation efforts of the last decade, by assessing Ireland's geodiversity. Geodiversity is the foundation of the biodiversity addressed under European Directives on habitats and species by the designations of Special Areas of Conservation (SAC) and more recently on a national scale by the introduction of Natural Heritage Areas (NHA) as the national nature conservation method. As a targeted conservation measure to protect the very best of Irish geology and geomorphology the IGH Programme fills a void which has existed since the abandonment of the Areas of Scientific Interest scheme, listed by An Foras Forbartha in 1981.

The IGH Programme does this by identifying and selecting the most important geological sites nationally for designation as NHAs. It looks at the entire spectrum within Irish geology and geomorphology under 16 different themes:

IGH THEMES

1. Karst
2. Precambrian to Devonian Palaeontology
3. Carboniferous to Pliocene Palaeontology
4. Cambrian-Silurian
5. Precambrian
6. Mineralogy
7. Quaternary
8. Lower Carboniferous
9. Upper Carboniferous and Permian
10. Devonian
11. Igneous intrusions
12. Mesozoic and Cenozoic
13. Coastal geomorphology
14. Fluvial and lacustrine geomorphology
15. Economic geology
16. Hydrogeology

A fundamental approach is that only the minimum number of sites necessary to demonstrate the particular geological theme is selected. This means that the first criterion is to identify the best national representative example of each feature or major sequence, and

the second is to identify any unique or exceptional sites. The third criterion, identifying any sites of International importance, is nearly always covered by the other two.

Designation of geological NHAs will be by the GSI's partners in the Programme, the National Parks and Wildlife Service (NPWS). Once designated, any geological NHAs will be subject to normal statutory process within the South Dublin County Planning Department and other relevant divisions. **However, compared to many ecological sites, management issues for geological sites are generally fewer and somewhat different in nature. The subsequent section considers these issues**.

From a national perspective, as a result of extensive comparison of similar sites to establish the best among them, there is now a good knowledge of many other sites, which are not the chosen best example, but which may still be of national importance. Others may be of more local importance or of particular value as educational sites or as a public amenity. All these various important sites are proposed for County Geological Site (CGS) listing in the County Development Plan.

Currently, in 2014, a Master List of candidate CGS and NHA sites is being used in GSI, originally compiled with the help of Expert Panels for all the 16 IGH themes. For several themes, the entire process has been largely completed and detailed site reports and boundary surveys have been done along with a Theme Report. Due to various factors, none have yet been formally designated. No sites in South Dublin County were so far considered to be of national importance nor been put forward as Natural Heritage Areas (NHA) for those few themes. Therefore, inclusion of all sites as County Geological Sites (CGS) in South Dublin County's planning system will ensure that they are not inadvertently damaged or destroyed through lack of awareness of them outside of the IGH Programme in GSI.

The sites proposed here as County Geological Sites (CGS) have been visited and assessed specifically for this project, and represent our current state of knowledge. It does not exclude other sites being identified later, or directly promoted by the Council itself, or by local communities wishing to draw attention to important sites for amenity or education with an intrinsic geological interest. New excavations, such as major road cuttings or new quarries, can themselves be significant and potential additions to this selection.

It was not possible within the scope of this study to identify landowners except in a few sites, but it is emphasised that CGS listing here is not a statutory designation, and carries no specific implications or responsibilities for landowners. It is primarily a planning tool, designed to record the scientific importance of specific features, and to provide awareness of them in any decision on any proposed development that might affect them. It thus also has an educational role for the wider public in raising awareness of this often undervalued component of our shared natural heritage.

Geological conservation issues and site management

Since **geodiversity is the often forgotten foundation for much of the biodiversity** which has been identified for conservation through SAC or NHA designation, it is unsurprising that many of the most important geological sites are actually in the same areas as SAC and NHA sites. In these areas, the geological heritage enhances and cements the value of these sites for nature conservation, and requires no additional designation of actual land areas, other than citation of the geological interest.

Broadly speaking, there are two types of site identified by the IGH Programme. The first, and most common, includes small and discrete sites. These may be old quarries, natural exposures on hilly ground, coastal cliff sections, or other natural cuttings into the subsurface, such as stream sections. They typically have a feature or features of specific interest such as fossils or minerals or they are a representative section of a particular stratigraphical sequence of rocks. **The second type of site is a larger area of geomorphological interest, i.e. a landscape that incorporates features that illustrates the processes that formed it**. The Quaternary theme and the Karst theme often include such sites. In South Dublin County, with a high proportion of land area under urban use, there are none of this type of sites.

It is also important from a geological conservation perspective that planners understand the landscape importance of geomorphological features which may not in themselves warrant any formal site designation, but which are an integral part of the character of South Dublin County. A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In South Dublin County a Landscape Characterisation Assessment was completed in 2008. This provides a tool for planners to help maintain the character of the County. An action in the Heritage Plan is to expand on the Assessment. The Strategic Environmental Assessment within the County Development Plan also provides tools. In addition, the now routine pattern of consultations with GSI, either by the planning department or by consultants carrying out Environmental Impact Assessment, plus strategic environmental assessment (SEA), has greatly improved the situation.

There are large differences in the management requirements for geological sites in comparison to biological sites. Geological features are typically quite robust and generally few restrictions are required in order to protect the scientific interest. In some cases, paradoxically, the geological interest may even be served better by a development exposing more rock. **The important thing is that the relevant planning department is aware of the sites and, more generally, that consultation can take place if some development is proposed for a site**. In this way, geologists may get the opportunity to learn more about a site or area by recording and sample collection of temporary exposures, or to influence the design so that access to exposures of rock is maintained for the future, or occasionally to prevent a completely inappropriate development through presentation of a strong scientific case.

In many counties, working quarries may have been listed because they are the best representative sections available of specific rock sequences, in areas where exposure is otherwise poor. No restriction is sought on the legitimate operation of these quarries. However, maintenance of exposure after quarry closure is generally sought in agreement with the operator and planning authority in such a case. At present, working quarries like

Belgard Quarry are now included as County Geological Sites in South Dublin County. These issues are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by the GSI and the Irish Concrete Federation in 2008.

A new quarry may open up a window into the rocks below and reveal significant or particularly interesting features such as pockets of fossils or minerals, or perhaps a karstic depression or cave. Equally a quarry that has finished working may become more relevant as a geological heritage site at that stage in its life. It may need occasional maintenance to prevent overgrowth of vegetation obscuring the scientific interest, or may be promoted to the public by means of a viewing platform and information panel.

Nationally, specific sites may require restrictions and a typical case might be at an important fossil locality or a rare mineral locality, where a permit system may be required for genuine research, but the opportunity for general collecting may need to be controlled. However, South Dublin County's sites are not likely to require such an approach.

Waste dumping

An occasional problem throughout the country, including in South Dublin County, is the dumping of rubbish in the countryside. The dumping of waste is not only unsightly and messy, but when waste materials are dumped in areas where rock is exposed, such as in quarries, they may leach into the groundwater table as they degrade. This can cause groundwater pollution and can affect nearby drinking water supplies in wells or springs. Groundwater Protection Schemes (DELG 1999) help to combat pollution risks to groundwater by zoning the entire land surface within counties into different levels of groundwater vulnerability. South Dublin County was included in a national scheme for Groundwater Protection in 2012, thus ranking the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', and helping planners to assess which developments are suitable or not in some areas of South Dublin County.

New exposures in development

One less obvious area where the Local Authority can play a key role in the promotion and protection of geology is in the case of new roads. **Wherever major new carriageways are to be built,** or in other major infrastructural work, it should be a policy within the Planning Department, that **where new rock exposures are created, they be left open and exposed** unless geotechnical safety issues arise (such as where bedding dips are prone to rock failure). The grading and grassing over of slopes in cuttings is largely a civil engineering convenience and a mindset which is difficult to change. However, it leads to sterile and uninteresting roads that look the same throughout the country. Leaving rock outcrops exposed where they are intersected along the road, improves the character and interest of the route, by reflecting the geology and landscape of the locality. Sympathetic tree or shrub planting can still be done, but leaving bare rocks, especially where they show interesting features, not only assists the geological profession, but creates new local landmarks to replace those removed in the construction of the roadway. This can also potentially save money on the construction costs.

Geoparks

An extremely interesting development in geological heritage, not just in Europe but internationally, has been the rapid recent growth and adoption of the Geopark concept. A **Geopark is a territory** with a well-defined management structure in place (such as Local Authority support), **where the geological heritage is of outstanding significance and is**

used to develop sustainable tourism opportunities. Initially it was largely a European Geoparks Network (EGN) but since 2004 has expanded worldwide as the Global Geoparks Network (GGN) and is fully assisted by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) [see www.globalgeopark.org and www.europeangeoparks.org]. A fundamental theoretical basis of the Geopark is that it is driven from the bottom up – the communities in the Geopark are the drivers of the project and are the main beneficiaries. The Geopark branding therefore helps promote the geological heritage resource so that the community can benefit from it.

In Ireland there are three members of the Geoparks Network. One is the cross-border Marble Arch Caves Global Geopark in Fermanagh and Cavan [see www.marblearchcaves.net and www.cavancoco.ie/marble-arch-caves-global-geopark]. The Copper Coast Geopark in Waterford also joined the Network in 2001 [see www.coppercoastgeopark.com]. A now well established addition has been the Burren and Cliffs of Moher in County Clare [see www.burrenconnect.ie/geopark]. In addition there are aspirant groups exploring the work and infrastructure required for applications in other areas such as Joyce Country in Mayo and Galway, and the cross-border Mourne-Cooley-Gullion area. At present, we do not consider the geodiversity in the county as likely to meet the criteria for a Geopark application, but it is conceivable that South Dublin County Council could become a partner if there was ever an attempt to form a 'Wicklow Mountains Geopark'.

Proposals and ideas for promotion of geological heritage in South Dublin County

The clear and significant inclusion of geological heritage in the South Dublin County Heritage Plan 2010-2015 is a most welcome and positive step, for a topic that is often undervalued and poorly known in the wider community. This section examines the existing points in the plan relating to geological heritage and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county.

1. Collate, record and disseminate heritage information

Objective 1: Establish the existing resource of heritage information in the County

i. Establish a County Heritage Database to collate archaeological, architectural, cultural and natural heritage records for the County.

Audit Action: The audit will contribute a dataset to this action and objective.

iii. In conjunction with the Geological Survey of Ireland, identify and collate information on geologically important sites in the County.

Audit Action: The audit will achieve this action entirely.

Objective 2: Gather heritage information

i. Identify the full range of features of architectural interest in the County, including those of local heritage interest, and implement a strategy to gain better understanding of their contribution to the County's heritage identity.

Audit Action: The audit may contribute to this action, in relation to sources of building materials used in heritage features.

vi. Support and promote the work of the County Library in its collection and digitization of local historical, cultural, and environmental heritage information.

Audit Action: The audit may contribute to this action, providing obscure geological references in an accessible format.

Objective 3: Provide better access to information

i. Develop a Heritage Website for South Dublin County which will act as a central hub for all heritage information for the County.

Audit Action: The audit may contribute to this action, providing data in an accessible format.

ii. Develop an interactive GIS system which would present all heritage information for the County in a usable and accessible manner.

Audit Action: The audit will contribute to this action, providing data in an appropriate GIS format.

v. Produce a Heritage Map of the County.

Audit Action: The audit may contribute to this action, providing data in an accessible format.

vi. Investigate strategies to improve the availability and distribution of heritage information books and leaflets currently produced by SDCC.

Audit Action: The audit may contribute to this action, providing data that could readily be turned into a new booklet or other format for public dissemination.

2. Provide information to raise awareness, appreciation and enjoyment of the County's heritage

Objective 1: Raise the profile of South Dublin County's rich and varied heritage

ii. Support the establishment of a County museum and assess the feasibility of establishing local heritage centres in conjunction with other stakeholders.

Audit Action: The audit could contribute to this action, by giving limited guidance as to important geological sites and themes if a museum or centre is established.

iii. Raise public awareness of the archaeological, architectural, and natural heritage of South Dublin County by publishing 'County Guides' to these heritage themes.

Audit Action: The audit could contribute to this action, providing the fundamentals for a geological guide. We would recommend production of a 'pubic-friendly' guide in plain language, with many images included, similar to those produced recently for Waterford, Fingal, Roscommon and Clare.

iv. Encourage local media in South Dublin County to give a higher positive profile to heritage issues and contribute regular articles on heritage to the Council's own newsletters.

Audit Action: The audit could contribute to this action, if the media can be encouraged to report on the geological heritage audit. The authors will endeavour to provide suitable press material after the audit.

v. Develop a programme to deliver awareness-raising exhibitions, conferences, seminars and training courses on heritage related issues to Council staff and the public in general.

Audit Action: The audit may contribute to this action, as the authors could deliver appropriate talks or seminars on the audit, once completed, for public or Council staff or the Heritage Forum. It is expected that the content for a panel image-based exhibition will be provided as a supplemental product of the audit. Such an exhibition could be physically displayed in Council venues, or simply made available on websites as a downloadable resource.

i. Highlight and promote the historic and national importance of the ancient trade and access routes through the lands of South Dublin County (e.g. Slí Mhór and Slí Chualann).

Audit Action: The audit may contribute to this action, in relation to the Greenhills esker for example.

v. Research and promote the significance of the County's long industrial heritage.

Audit Action: The audit may contribute to this action, providing data on economic resource (geological) exploitation.

vii. Promote the industrial, natural, historical, and architectural heritage of the County's waterways e.g. the Grand Canal, the River Liffey, the River Dodder etc.

Audit Action: The audit may contribute to this action through more general understanding of the siting of the waterways heritage as influenced by geological and Earth resource factors.

Objective 4: Encourage active participation and enjoyment of heritage features

i. Support the sustainable development of walking routes and heritage trails throughout the County, developing a design concept for signage to secure a high quality, coordinated approach to heritage display information.

Audit Action: The audit may contribute to this action by ensuring that geological heritage components are incorporated into any trails or walking routes, where feasible, and that geodiversity information features in display information.

Objective 5: Develop and support education initiatives to improve understanding of heritage issues in the County.

ii. Develop and promote an architectural education information pack for schools.

Audit Action: The audit may contribute to this action, if relevant, by providing data on Earth materials used in architectural heritage, and in modern building materials.

iii. Develop a strategy with project partners to develop additional heritage educational programme or delivery to other interest groups such as secondary schools and adult education initiatives.

Audit Action: The audit may contribute to this action, if the authors provide one-off geological heritage events, arising from the audit and its promotion. The authors contribute to groups such as Earth Science Ireland on a long term basis, whose role is more aligned with this action.

iv. Promote research into aspects of South Dublin County's natural, cultural, built, and historic heritage by encouraging partnership projects with educational, professional institutions, and business enterprises.
Audit Action: The audit arises from one such partnership and it is envisaged by the authors that future collaboration with geologically based groups is likely to occur, building on this foundation.

3. Promote best practice with regard to heritage conservation and management

Objective 1: Develop policies and frameworks to direct the management of heritage in the County
i. Forge strong operational links between the objectives of the Heritage Plan and those of other County development strategies such as the County Development Plan and the work of the County Development Board.
Audit Action: The audit provides a direct link in achieving an action of the plan that also feeds into the County Development Plan.

iv. Undertake an audit of all protected structures and designated sites (Natural Heritage Areas) in SDCC ownership and promote a high standard of maintenance and conservation management of such properties.
Audit Action: The audit may contribute to this action for relevant sites.

Objective 2: Promote and assist in the design of an integrated Network of Green Spaces for the County.
i. Continue to develop a sustainable, integrated, network of green spaces in the County that will provide a functioning, sustainable, connective link for people and wildlife between parks, protected sites, gardens, and other areas of biodiversity, geological and recreational importance.
Audit Action: The audit will provide clarity on areas of geological importance and where they overlap with other green spaces.

ii. Support and assist the advancement of the objectives as stated in the County Development Plan 2010-2016 in relation to the development of the Liffey Valley Park and the provisions for a Dodder Linear Park and other projects relating to similarly important riverine systems.
Audit Action: The audit contributes to this action with baseline information for the relevant sites.

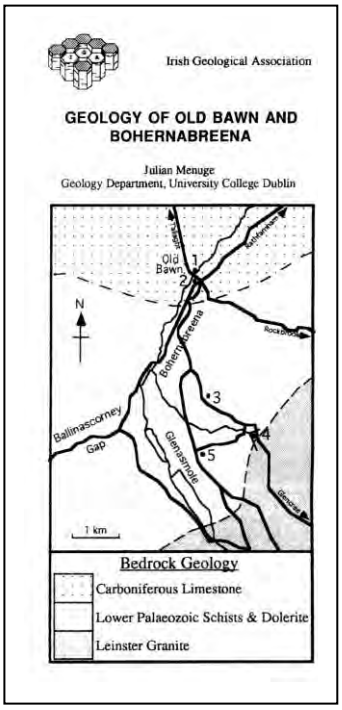
4. Establish and promote partnerships to achieve heritage objective

Objective 1: Develop links with local groups and interest groups to more fully integrate heritage issues into local consciousness.
i. Assist in the development of local pride and sense of place by facilitating and supporting community development initiatives to incorporate and promote heritage in local projects.
Audit Action: The audit will allow opportunities for popular articles in magazines such as *Earth Science Ireland* that may be used by the Heritage Officer to develop local awareness and pride.

Objective 2: Engage with businesses and national and local agencies to accomplish shared objectives
iii. Develop links between SDCC and other agencies at a national, regional, County, and local level, to work together to address heritage related issues within the County.
v. Liaise and co-operate with state bodies and other agencies in relation to the protection of natural heritage designations in the County.
Audit Action: The audit builds a relationship with the Geological Survey of Ireland for the proper assessment of geological heritage within planning and promotional issues.

vi. Develop co-operative projects with adjacent County Council areas to accomplish shared heritage objectives.
Audit Action: As Dun Laoghaire Rathdown, Dublin City and Wicklow are all being audited at the same time, opportunities to promote the results of the audits, or possible follow-on exhibitions, books, apps, trails or leaflets on geological heritage may best be done as joint projects.

Specific ideas for projects



Leaflets
No existing leaflets on the geological heritage of South Dublin County are known, except for an old IGA guide to Old Bawn and Bohernabreena. There is some scope for other and different leaflets. Any leaflets produced could simply be made available as pdf downloads on the Council's website to avoid large costs of printing.

Guides
There are few existing guides to the geology of South Dublin County, apart from some GSI literature produced some time ago. The 1:100,000 map report for Sheet 16 covers South Dublin County and is an essential resource. For general interest, *Wicklow in the Ice Age* was a useful resource. Although out of print it is available digitally from GSI. An excellent practical field guide to Leinster's Geology by Chris Stillman and George Sevastopulo is still in print through Dunedin Academic Press.

There is scope for guides at different levels of detail and accessibility to non-specialists. A wide range of leaflets, booklets, books and other media are all feasible, but the research and production of appropriate text and images is a difficult task to do well without appropriate experience, and adequate time and resources. It is suggested that **with only modest editing and reorganisation the main content of this report would distil into a good general short guide to the geological heritage of South Dublin County**, in a broadly similar style to those books produced for Sligo, Meath, Fingal, Waterford, Roscommon and Clare following audits in those counties. Some consideration could be given to the idea of a combined DLR, South Dublin and Dublin City book.

Signboards
Simple explanatory or interpretive signboards may be advisable at key geological heritage locations, but if these are considered, their locations and individual siting should be very selective, since a proliferation of different interest groups may provoke a 'rash' of panels all over the county. The Planning Section should clearly have a controlling input, in conjunction with the Heritage Office. It is most likely that a panel combining various heritage interests at a place is preferred to single interest panels. It is important to consult with potential partners in the planning stage so that duplication does not occur.

The successful integration of text and graphics on information panels is a fine art, and the IGH Programme can offer input if signs are planned for key visitor localities. The authors of this report are also able to write, review or provide content on geological heritage for any proposed panels.

Museum exhibitions
As a result of the work to produce this report, the material for a panel based exhibition has been largely compiled. With some extra research covering human dependence on geology and resources, an interesting exhibition can be put together for display in the South Dublin County Council Offices, County Library branches or other venues. The model followed was that used for Carlow, Dun Laoghaire-Rathdown and Waterford. Images of those and other

similar ones can be seen on the Geological Heritage/Exhibitions section of the GSI website [www.gsi.ie].

New media
There are increasing numbers of examples of new methods of promoting Earth Sciences, via mobile phone applications and other electronic media. Self-guiding apps on specific sites would be one of these, such as those produced by Ingenious Ireland for Dublin city geology and the recently launched app for tourists in the Burren and Cliffs of Moher Geopark. Plans for such products would require some considerable effort to produce and imaginative effort, to link sites in any coherent ways, other than by their county.

Earth Science Ireland Group and magazine [www.earthscienceireland.org]
The group Earth Science Ireland is an all-Ireland group promoting awareness of Earth sciences and supporting educational provision in the subject. A main vehicle for the efforts is the twice a year magazine *Earth Science Ireland* and this is distributed free to thousands of individuals, schools, museums, centres and organisations. The editors would welcome more material from the Republic of Ireland and on South Dublin County's geological heritage. It is anticipated by the authors of this report that they will contribute a summary article distilled from the audit report.

Geoschol website [www.geoschol.com]
Geoschol is an educational project, now essentially represented by a website, which was largely aimed at producing educational materials on geology for primary schools. A four page pdf summarising the geology and some highlights of South Dublin County is already part of the available material (see Appendix 6). Working links to the Heritage section of South Dublin County Council's website, as well as to other heritage websites, should be established.

Geological Heritage Research Archive
If the Heritage Officer wanted to do something similar to that produced in the Burren and Cliffs of Moher Geopark, with downloadable (or links to) free access papers, then a lot of groundwork is already provided by the reference lists in this audit. Making available technical references of direct relevance to South Dublin County geology and geomorphology will assist many users and researchers into the future. However, consideration should be given to making this a combined Dublin archive if it is desired, since the geology knows no administrative borders, but is linked throughout the 4 authority areas.

Maps
A series of popular maps of the Wicklow and Dublin Mountains produced by East West Mapping at a scale of 1:30,000 have been very innovative in taking the geological heritage site data from GSI and including it on the maps. This has been as point data. The completion of the audit will allow future editions of these maps to have more accurate data, with rejected sites removed, new sites added and area definitions if desired. It is hopefully a data layer that might also be adopted by the Ordnance Survey of Ireland in their future map editions of the 1:50,000 Discovery Series, for all counties where an audit has been completed. Similarly a Dublin Mountains Partnership map of the Dublin-Wicklow hills could also be improved in future editions by adding geological heritage site data.

A summary of the Geology of South Dublin County

1) Paragraph summary

South Dublin has three main geological areas. The oldest is composed of Ordovician volcanic rocks and Silurian sedimentary rocks in the south western part of the county. These were formed as ancient sea floor rocks around 470 to 440 million years ago. They were uplifted into land as part of the Caledonian mountain building event at the end of the Silurian Period. Shortly after, big masses of granite were injected into them during the Devonian Period at around 405 million years ago. South Dublin includes the northern end of the Leinster Granite chain. The northern half of the county is formed of Carboniferous Limestone rocks deposited in a deep marine basin. These rocks were formed around 340 million years ago and are faulted against the older rocks along the base of the mountains. Over the last 2 million years the Ice Age had a big effect on the landscape, eroding the mountains, depositing glacial gravels in places and then rivers such as the Dodder have been active in recent times, modifying the sediments at surface.

AGE (Million Years Ago)	ERA	PERIOD	EVENTS IN SOUTH DUBLIN	IF THIS TIMESCALE WERE A DAY LONG ...
2.6	Cenozoic	Quaternary	Several ice ages smothering South Dublin, followed by the spread of vegetation, growth of bogs and arrival of humans in the last 10,000 years. Shaping of bedrock in the Dublin mountains. Meltwater sculpts deep channels and deposits sands and gravels during deglaciation.	The ice ages would begin 38 seconds before midnight
66		*Tertiary*	*Erosion, weathering of rocks and denudation of land surface.* *No record of rocks of this age in South Dublin.*	The Tertiary period begins at 11.40 pm
145	Mezozoic	*Cretaceous*	*Erosion.* *No record of rocks of this age in South Dublin.*	11.15 pm
201		*Jurassic*	*Uplift and erosion.* *No record of rocks of this age in South Dublin.*	The age of the dinosaurs, starting at 10.55 pm
252		*Triassic*	*Desert conditions on land.* *No record of rocks of this age in South Dublin.*	10.42 pm
298	Palaeozoic	*Permian*		10.30 pm
359		Carboniferous	Land became submerged, limestones with some shales and sandstones deposited in tropical seas across much of the northern portion of South Dublin. Limestones remaining today are impure and unbedded in the majority, with smaller areas of muddier limestones at the edges.	Inundation of land by sea around 10.10 pm
419		Devonian	Caledonian mountain building. Leinster Batholith Granite intruded, forming Dublin Mountains.	Granite intruded into Dublin Mountains, at 9.52 pm
443		Silurian	Shallow seas, following closure of the Iapetus Ocean. Slates, greywacke and shales deposited along southeastern extreme of South Dublin.	Starts at 9.42 pm
485		Ordovician	Slates, siltstones and volcanic rocks form across much of the southern portion of South Dublin.	Begins at 9.28 pm
541		*Cambrian*	*Opening of the Iapetus Ocean.* *No record of rocks of this age in South Dublin.*	Starts at 9.11 pm
2500	Proterozoic	*Precambrian*	*Some of Irelands oldest rocks deposited in Mayo and Sligo.*	Beginning 11.00 am
4000	Archaean		*Oldest known rocks on Earth.*	Beginning 3.00 am
4600			*Age of the Earth.*	Beginning 1 second after midnight

The Geological Timescale and South Dublin County

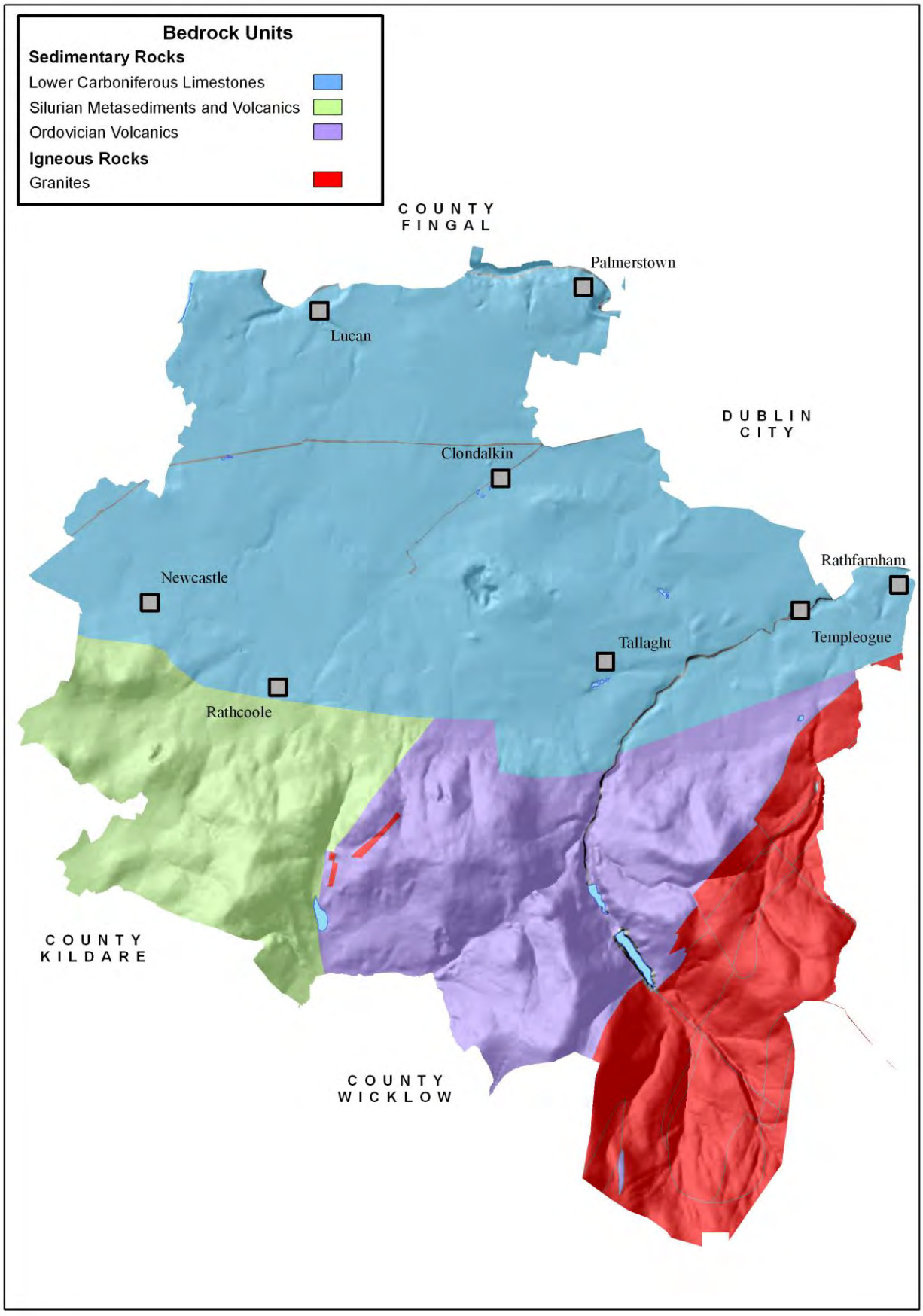
2) Simple summary

South Dublin has three main geological areas. The oldest is composed of Ordovician volcanic rocks and Silurian sedimentary rocks in the south western part of the county. These were formed as ancient sea floor sediments around 470 to 440 million years ago. They were uplifted into land as part of the Caledonian mountain building event at the end of the Silurian Period. They were on the southern side of the Iapetus Ocean which separated two 'halves' of Ireland, and which drifted northwards to combine – forming mountains through the Appalachians, Ireland, Scotland and into Scandinavia.

Shortly after, as a result of the collision of the continental masses, big masses of granite were injected into them during the Devonian Period at around 405 million years ago. The chain of three main granite bodies runs down through Wicklow and Carlow. South Dublin includes the northern end of the Leinster Granite chain. As well as the granite, which was intruded to near surface levels, there was a series of dolerite dykes intruded across South Dublin, which are seen today in Ballinascorney Quarry.

The northern half of the county is formed of Carboniferous Limestone rocks deposited in a deep marine basin. These rocks were formed around 340 million years ago and are faulted against the older rocks along the base of the mountains. The limestone deposited in this basin is a muddy limestone with few fossils, as it was generally a deeper water environment. This limestone underlies most of Dublin and is known as Calp limestone or 'the Calp'. It is well displayed in the Belgard Quarry.

Some areas of very flat terrain such as around Newcastle actually conceal a buried topography from interglacial and pre-glacial periods. Drilling for minerals in the area revealed very deep channels filled with gravels, representing the route of a very large river from former times. Over the last 2 million years the Ice Age had a big effect on the landscape, eroding the mountains and depositing glacial gravels in places, especially around Brittas. Since the ice sheets melted away, rivers such as the Dodder have been active in the last 10,000 years or so, modifying the sediments at surface. River terraces are seen in the Dodder valley.



A simplified geology map of South Dublin County outlining the main geological units.

Geological heritage versus geological hazards

Ireland is generally considered to be a country with very low risk of major geological hazards: there are no active volcanoes, Ireland's location on stable tectonic plates mean earthquakes are relatively rare and its recorded human history is not peppered with disastrous landslides, mudflows or other geological catastrophes. There are of course risks of one-off events, and this section briefly looks at the specific record and nature of geological hazards in South Dublin County and the relationship of the County Geological Sites to those hazards.

The difference between human timescales and geological timescales can be difficult to comprehend but, for many geological processes, there are periods of sudden activity encompassing major events, and then quiet periods in between. The sites in this audit represent evidence of past geological environments and processes, such as the building of high mountain chains, deep intrusion of massive granite bodies, volcanic rock intrusions, glacier erosion of the land surface and so on. However, in South Dublin County there are few sites representing the active geomorphological or land-forming processes of today, but the River Dodder is one such. These are dynamic environments and can be subject to constant or intermittent, sometimes sudden, change.

Landslides and bog flows
The Geological Survey of Ireland has been compiling national data on landslides in the past decade. There were 40 events recorded in Dublin, but the data does not discriminate between the separate local authorities.
See http://www.gsi.ie/Programmes/Quaternary+Geotechnical/Landslides/

Flooding
There are two types of flooding which need consideration. River flooding occurs inland when the rainfall exceeds the capacity of the ground to absorb moisture, and the river channels cannot adequately discharge it to the sea. The OPW website, www.floods.ie, can be consulted for details of individual flood events in South Dublin County. Karstic flooding can occur when underground passages are unable to absorb high rainfall events. The Carboniferous limestone bedrock in South Dublin County is of a type called 'Calp' which can have extensive shale beds within it, and it tends not to become heavily karstified.

Radon
Radioactive minerals and gases at higher concentrations can be carcinogenic. Radon can seep into homes and workplaces and can be carried in water supplies. A map showing the areas predicted to be at particular risk from radon in Ireland, called High Radon Areas, can be seen on the EPA website at http://www.epa.ie/radiation/#.VRu9OVROPcs. The Radiological Protection Institute of Ireland was formerly responsible for this but has been merged with the EPA.

Glossary of geological terms

Geological term	Definition
Alluvial Deposit	unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Alluvium	a term for unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Appinite	plutonic igneous rock formed from hydrous magma of mantle origin, dioritic in composition, i.e. rich in hornblende, also containing plagioclase feldspar and/or alkali feldspar, with or without quartz; typically associated with breccia pipes in Donegal
Basin	low areas in the Earth's crust, of tectonic origin, in which sediments have accumulated.
Bedrock	a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
Blanket Bogs	bog covering a large, fairly horizontal area, which depends on high rainfall or high humidity, rather than local water sources for its supply of moisture.
Boulder Clay	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt. Also known as till.
Braided River	a river that consists of a network of small channels separated by small and often temporary islands called braid bars.
Calp	dark grey, fine-grained, muddy limestone
Channel	a landform consisting of the outline of a path of relatively shallow and narrow body of fluid, most commonly the confine of a river,river delta or strait.
Crag and tail	a steep resistant rock mass (crag), with sloping softer sediments (tail) protected from glacial erosion or deposited as glacial debris on the crag's 'downstream' side.
Dip/dipping	when sedimentary strata are not horizontal they are dipping in a direction and the angle between horizontal and the inclined plane is measured as the dip of the strata or beds
Erratic	a large rock fragment that has been transported, usually by ice, and deposited some distance from its source. It therefore generally differs from the underlying bedrock, the name "erratic" referring to the errant location of such boulders. Tracing their source can yield important information about glacial movements.
Esker	an elongated ridge of stratified sand and gravel which was deposited in a subglacial channel by meltwaters. Eskers are frequently several kilometers in length.
Fan	a usually triangular deposit of sand and gravel deposited by a glacial stream, either under a lake or under air.
Floodplain	a flat or nearly flat land area adjacent to a stream or river that experiences occasional or periodic flooding.
Flute (glacial)	smooth gutter-like channels or furrows made by the abrasive underside of a glacier moving across a rock face.
Fluvial	pertaining to a river or stream.
Glacial	of or relating to the presence and activities of ice or glaciers.
Glacial striae	markings left on the surface of pebbles / boulders / bedrock by moving ice sheets.
Glaciofluvial	pertaining to the meltwater streams flowing from wasting glacier ice and especially to the deposits and landforms produced by such streams.
Grading	a sorting effect with the coarsest material at the base of the bed and finest grained material at the top.
Grus	crumbled granite sand formed by weathering
Gully	a deep valley created by running water eroding sharply into bedrock or subsoil
Hummock	a small hill or knoll in the landscape, which may be formed by many different processes.
Ice margin	the edge of an ice sheet or glacier

Igneous	a rock or mineral that solidified from molten or partially molten material i.e. from a magma.
Interglacial	the time interval between glacial stages, or pertaining to this time
Irish Sea Till	clay-rich till found along the eastern seaboard of Ireland, and occurring as much as 12km inland, which was deposited by an ice stream which occupied the Irish Sea Basin during the last glaciation.
Limestone	a sedimentary rock consisting chiefly of calcium carbonate (CaCO3), primarily in the form of the mineral calcite.
Lithology	the description of rocks on the basis of such characteristics as colour, composition and grain size.
Lodgement	process by which debris is released from the sliding base of a moving glacier/ice sheet and plastered or 'lodged' onto the glacier bed; also describes tills emplaced by this process (i.e. lodgement till).
Meander	a bend in a sinuous watercourse or river which forms when moving water in a stream erodes the outer banks and widens its valley, and the inner part of the river has less energy and deposits fine sediment.
Meltwater	water from melted snow or ice.
Meltwater channel	a channel cut by glacial meltwater, either under, along or in front of an ice margin.
Metamorphic	referring to the process of metamorphism or to the resulting metamorphic rock, transformed by heat and pressure from an originally igneous or sedimentary rock.
Misfit stream	a stream which is too small to have eroded the valley in which it flows, as is often the case with streams now flowing in meltwater channels.
Moraine	any glacially formed accumulation of unconsolidated debris, in glaciated regions, such as during an ice age.
Nunatak	an exposed, often rocky element of a ridge, mountain, or peak not covered with ice or snow poking up above an ice sheet or glacier.
Outcrop	part of a geologic formation or structure that appears at the surface of the Earth.
Outlier	area of younger bedrock completely surrounded by older bedrock
Oxbow lake	a U-shaped body of water that forms when a wide meander from the main stem of a river is cut off, creating a free-standing body of water
Peat hag	solitary banks of peat standing proud of surrounding areas of eroded and removed peat
Raised Bogs	an area of acid, peaty soil, in which the centre is relatively higher than the margins.
Sandur	a plain formed of glacial sediments deposited by meltwater outwash at the terminus of a glacier
Shale	A fine-grained sedimentary rock, formed by the compaction and lithification of clay, silt, or mud. It has a finely laminated (composed of layers) structure that gives it a fissility, or tendency to split along bedding planes.
Spring	the point where an underground stream reaches the surface.
Terrace	terraces are remnants of the former floodplain of a stream of river, formed by the downcutting of a river or stream channel into and the abandonment and lateral erosion of its former floodplain
Till	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock as sand, silt or clay.

Data sources on the geology of South Dublin County

This section is a brief summary of relevant GSI datasets, to assist any enquiry concerning geology and to target possible information easily. The GSI has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A Document Management System (DMS) is freely available to any person at the GSI Customer Centre, into which about half a million documents and maps have been scanned. This means that any user can visit the GSI Customer Centre themselves and search on screen for data of relevance to them. High quality colour and black and white print-outs can be made or data supplied on CD, or via USB keys etc. **Data is available free of charge**. It is planned to make this resource available online within the next year, although many subsets are already available within existing online data sets.

Key datasets include:

1:100,000 Map Report Series

All historical, modern and other mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Sheet 16 covers South Dublin County.

19th century 6 inch to the mile fieldsheets

These provide an important historical and current resource, with very detailed observations of the geology of the entire country.

19th century one inch maps and Memoirs

Information from the detailed 19th century mapping was distilled into one inch to the mile maps, of which parts of Sheets 111, 112, 120 and 121 cover South Dublin County. Each sheet or several sheets were accompanied by a Memoir which described the geology of that area in some detail. These still provide valuable records of observations even though interpretations may have changed with better geological understanding. Memoirs are in the Customer Centre library and scanned on the DMS.

Historical geological mapping is now available via a website:
http://www.geologicalmaps.net/irishhistmaps/history.cfm

Open File Data

Each Mineral Prospecting Licence issued by the Exploration and Mining Division (EMD), currently of the Department of Communications, Energy and Natural Resources, carries an obligation on the exploration company to lodge records of the work undertaken, for the common good. These records are held by the Geological Survey and are available as Open File Data, once a period of time has expired. They may include geological interpretations, borehole logs, geophysical and geochemical surveys and so on. Licences relate to numbered prospecting areas, and these are available on a map from EMD. See also www.mineralsireland.ie

MinLocs Data

The MinLocs Database records all known mineral occurrences, however small, from GSI records, such as 19th century fieldsheets and Open File data.

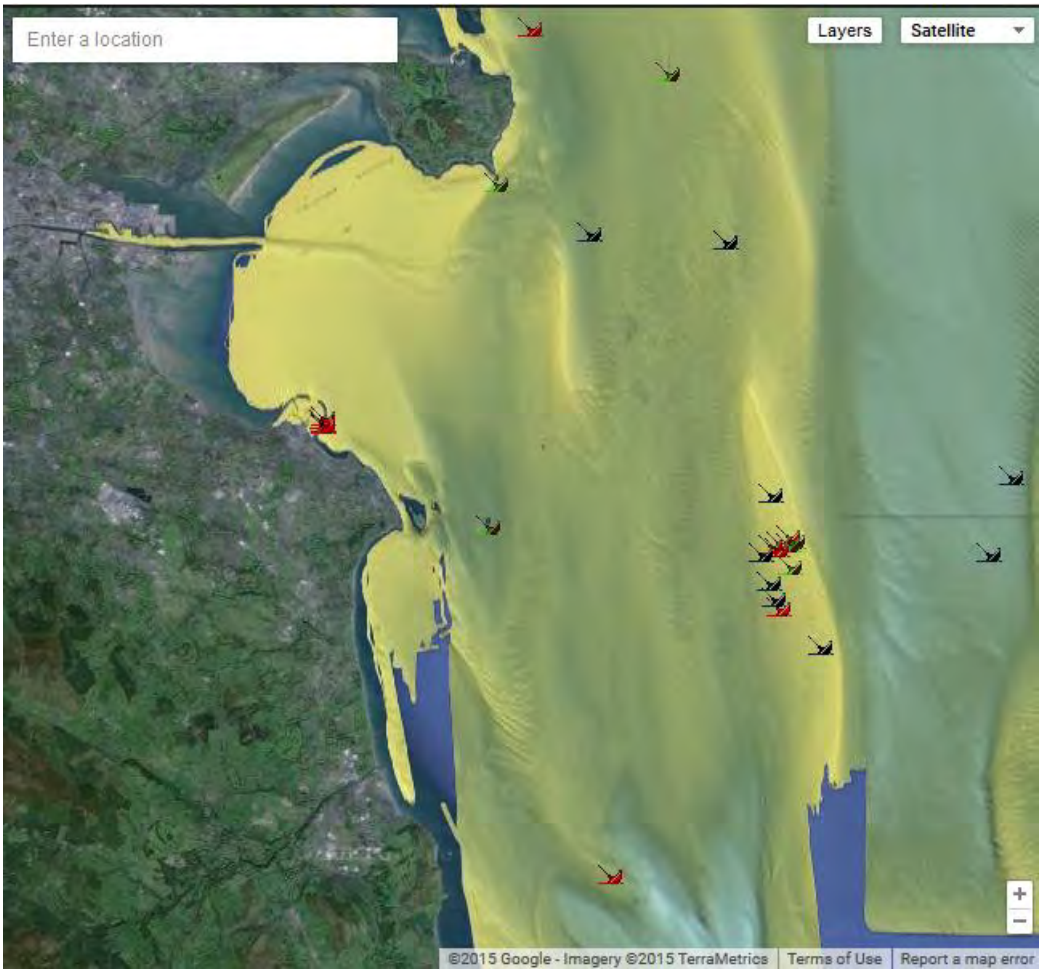
Historic Mine Records

Abandonment plans and varied other material exists for the various mining ventures in the country. Nothing specific is known for South Dublin County.

Subsoils Mapping
Since a Groundwater Protection Scheme has been completed by GSI (2012) for the whole country, a modern map of the subsoil types and depths across South Dublin County exists, as well as the previously completed bedrock mapping. This provides a significant resource in general terms as well as for groundwater protection. Customised output is possible. Furthermore, detailed compilation of glacial geology datasets, including a revision to be published by GSI in late-2014, will provide more data from late 2014 onwards.

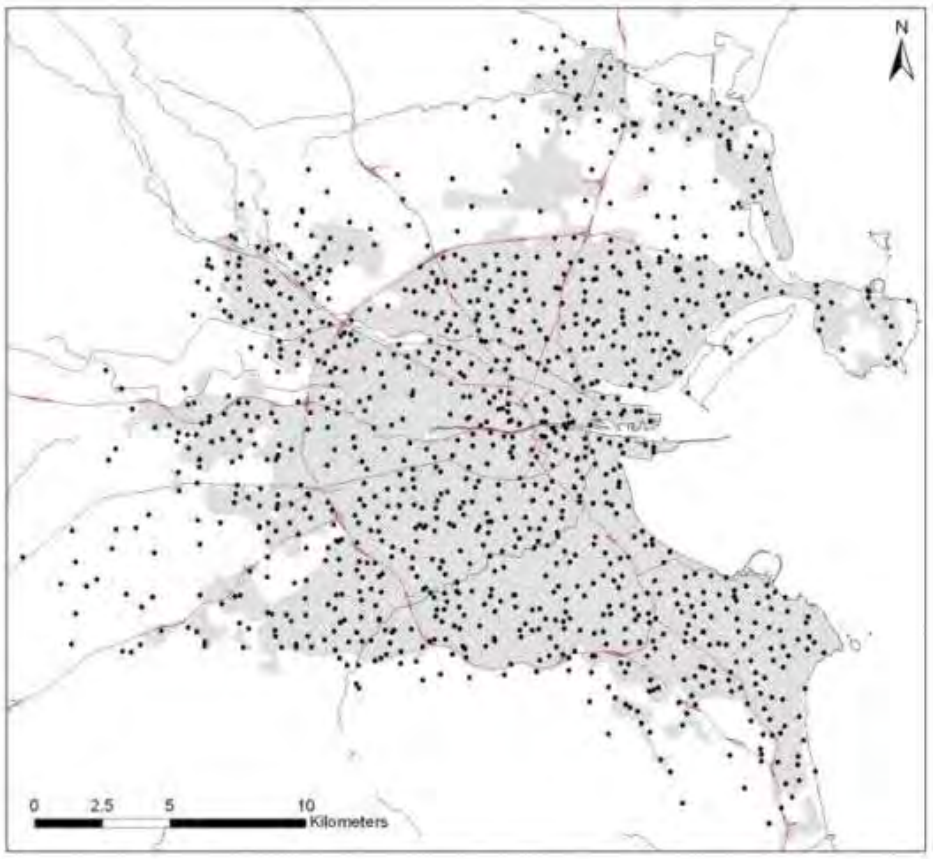
Digital mapping of many different datasets is now available via an easy to use public viewer on the GSI website: www.gsi.ie

Infomar data
Although South Dublin County has no coast, this section is included as part of a wider context and interest for the whole of Dublin. The Infomar Programme in the GSI is mapping the seabed in targeted areas of the inshore coast of Ireland. The graphic below shows offshore in Dublin Bay, with some of the many wrecks identified by the survey. Infomar data is freely available for analysis and further processing from the Infomar data via the GSI website.
http://www.gsi.ie/Programmes/INFOMAR+Marine+Survey/
See also www.informar.ie



Dublin SURGE Project (Soil Urban Geochemistry)

GSI has carried out a chemical survey of the topsoil around Dublin city and county in 2012. It involved taking and analysing samples of soil from areas that are publicly accessible (e.g. public parks and school grounds). The aim of the survey was to acquire important information about Dublin soils that will help to better manage the environment.



Shortlist of Key Geological References
This reference list includes a few **key** papers, books and articles on the geology and geomorphology of South Dublin County that are recommended as access points to South Dublin County's fabulous geological heritage.

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Full Geological references
See Appendix 2 for the full reference list of all papers, books, articles and some unpublished reports etc relating to the geology and geomorphology of South Dublin County that could be traced. Many papers that refer to the Dublin area may or may not be specifically relevant to South Dublin County.

Quaternary References
The references in Appendix 3 all cover the Quaternary, or Ice Age, geology of South Dublin County. They are split into references specifically covering sites or features in South Dublin County, and a section of national or regional papers which have some data from or on South Dublin County included.

Further sources of information and contacts

Sarah Gatley of the Geological Survey of Ireland, who is the Head of the Geological Heritage and Planning Programme, can be contacted in relation to any aspect of this report. Rosaleen Dwyer, the Heritage Officer of South Dublin County Council is the primary local contact for further information in relation to this report. Other contacts include the Conservation Rangers of the National Parks and Wildlife Service, currently in the Department of Arts, Heritage and the Gaeltacht. The names and phone numbers of current staff may be found in the phone book, or at www.npws.ie.

Web sites of interest

www.gsi.ie - for general geological resources
www.geology.ie – the website of the Irish Geological Association who run fieldtrips and lectures for members, including many amateur enthusiasts
www.earthscienceireland.org - for general geological information of wide interest
http://www.iqua.ie - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history
http://www.progeo.se/ - for information about ProGEO the European Association for the Conservation of Geological Heritage

Acknowledgements

The authors would like to gratefully acknowledge the assistance of Rosaleen Dwyer, Heritage Officer from South Dublin County Council in the development of this project. Funding from the Heritage Council and South Dublin County Council is also acknowledged. We also acknowledge the many members of the IGH Programme Expert Panels who helped define the sites which were considered for County Geological Site status. Ciaran Greenan and Ernie Bohan of Roadstone are thanked for providing access to Belgard Quarry for the purposes of the audit. Gareth Ll. Jones very kindly provided unpublished data on the Newcastle Buried Channel site, enabling this audit report to be completed. David Ball gave very generously of his time, to the assessment of the status of Grange Castle Golf Course Well, which is now unfortunately in the rejected site appendix.

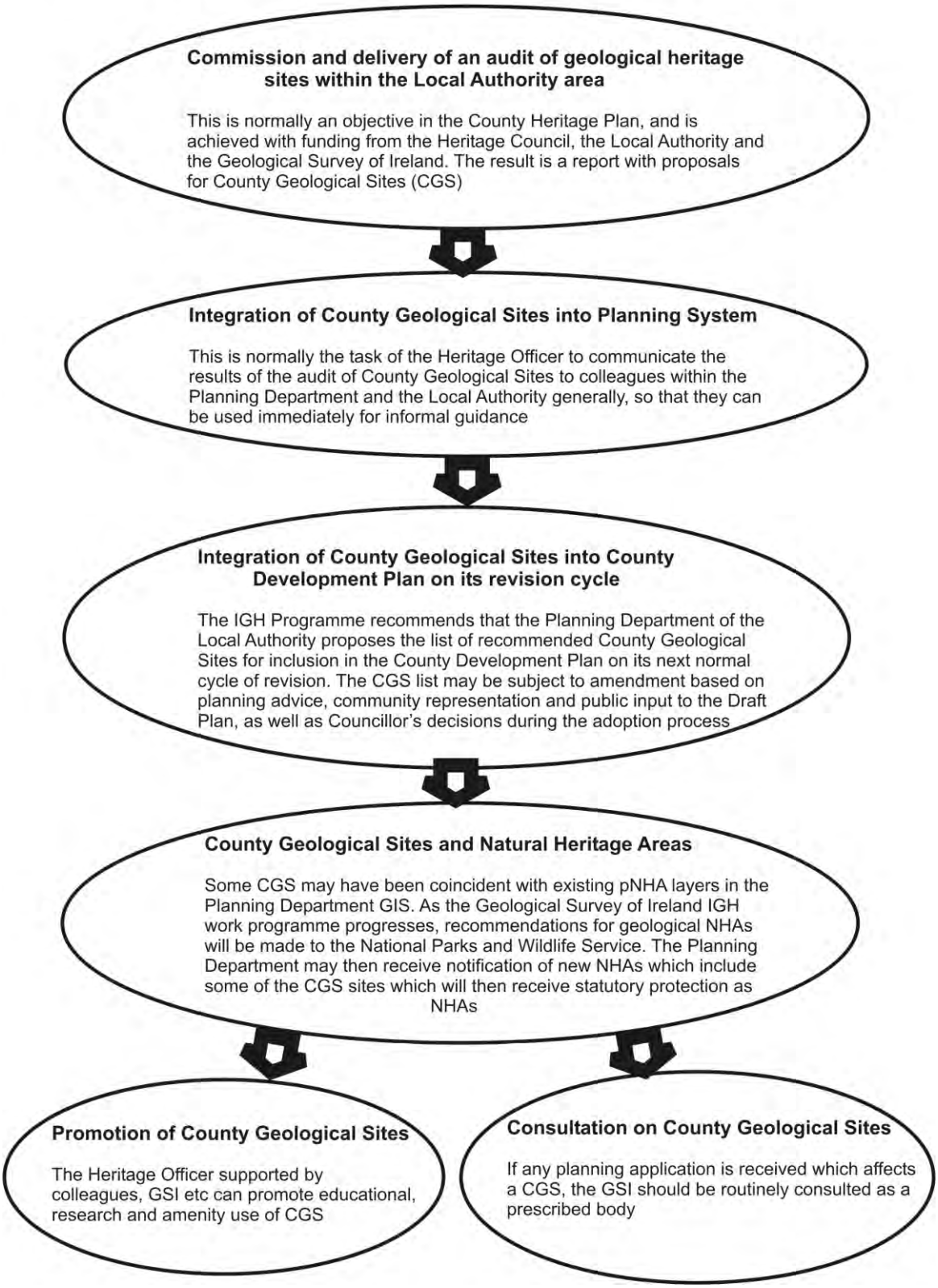
Appendix 1 – Geological heritage audits and the planning process

This appendix contains more detail on the legal framework behind geological heritage audits conducted by County Councils, and the process which operates as a partnership between the Geological Heritage and Planning Programme of the GSI and the local authority Heritage Officer.

Geology is now recognised as an intrinsic component of natural heritage in three separate pieces of legislation or regulations, which empower and require various branches of Government, and statutory agencies, to consult and take due regard for conservation of geological heritage features: the Planning and Development Act 2000 [e.g. Sections 212 (1)f; Part IV, 6; First Schedule Condition 21], the Planning and Development Regulations 2001, the Wildlife (Amendment) Act 2000 (enabling Natural Heritage Areas) and the Heritage Act 1995. The Planning and Development Act 2000 and the Planning Regulations, in particular, place responsibility upon Local Authorities to ensure that geological heritage is protected. Implementation of the Heritage Act 1995, through Heritage Officers and Heritage Plans, and the National Heritage Plan 2002, allow County Geological Sites to be integrated into County Development Plans.

The chart below illustrates the essential process, established by the Irish Geological Heritage Programme in GSI, over the course of numerous county audits since 2004.

County Geological Sites - a step by step guide



Appendix 2 - Bibliography – Geology of South Dublin County

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Appendix 3 - Bibliography – South Dublin County Quaternary References

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Appendix 4 – Rejected sites

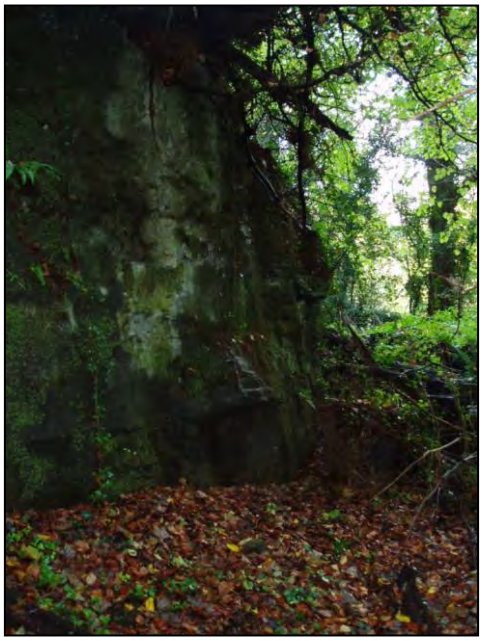
A range of sites had been previously flagged for consideration in the IGH Master site list, and some were assessed as unsuitable for County Geological Site status in this audit. Similarly a range of additional sites were assessed in the audit, based on the authors' expert knowledge of South County Dublin's geology, and especially along the Liffey and Dodder river valleys. It was known, for example, that meltwater landforms such as eskers and gravel terraces in South County Dublin had not been adequately considered in the preparation of the IGH Master site list. Other sites were visited on spec during fieldwork. The rejected sites are listed below with brief notes as to why they were assessed as unsuitable for inclusion.

Clondalkin Quarries
The quarries in Clondalkin were originally listed for the Lower Carboniferous Theme, as there were limestones exposed here that had layers near their base rich with pebble of granite, presumably derived from erosion of the Devonian Leinster Granite to the south. These would have been evidence of the exposure of the granite bodies by that time, and also evidence of palaeocurrents from the high ground southwards, delivered into the basin. However, the description of these layers was from the 1970s.

The quarries are rejected as CGS in this audit, because there is virtually no quarry still in existence. Urban development and backfill with construction and demolition waste appears to have obscured all but mere fragments of any former quarry.

Top: Panorama view of the former quarry.
Bottom left: Some of the builder's rubble infill, looking into a flat floor of former quarry area.
Bottom right: Some of the builder's rubble infill which is an elevated pile in central areas.

Fonthill Tufa
The undifferentiated Calp limestone in Fonthill, near the Liffey Valley shopping centre, is lime-rich, meaning that a thick sheet of tufa has formed within some disused quarries there. This means their outcrops are much 'dirtier' and more obscured. Though this is unusual, nothing observed at the site was of sufficient importance to consider it a County Geological Site.



Undifferentiated Calp limestone outcropping in a deep, disused quarry close to the stream gully, and just north of the lake, at Fonthill. See the whitish sheets of tufa obscuring the rock, formed from seepages of water between rock units higher up in the section.

Glenasmole Tufa
Small seeps in a forest at Glassamucky near Glenasmole are also lime-rich, meaning that patches of tufa have formed in places. However, given that the springs are susceptible to burial by landslides and are not especially important in a geological sense, nothing observed during the audit of the site was of sufficient importance to consider them a County Geological Site.

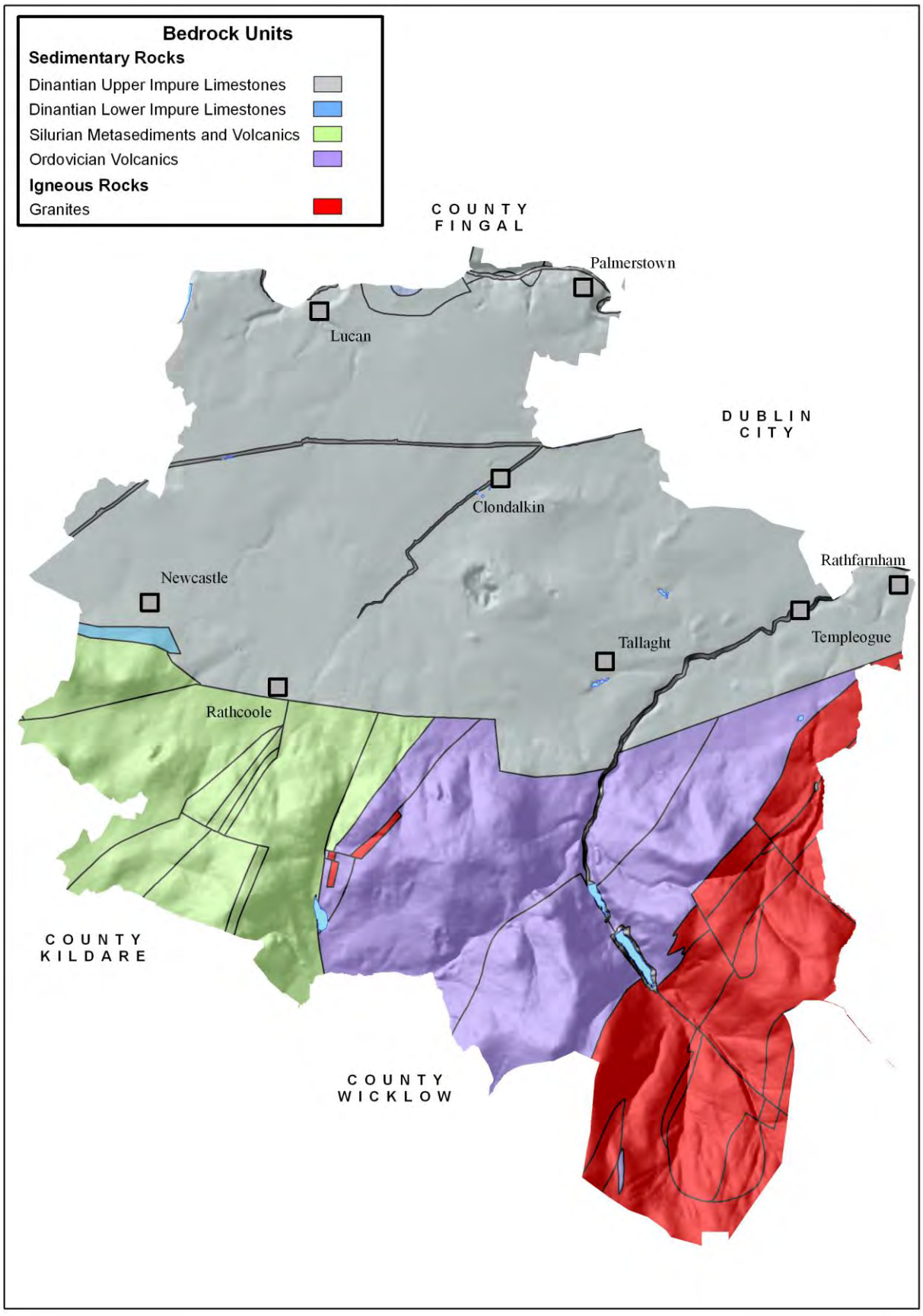
Grange Castle Golf Course Well
This well was drilled on behalf of South Dublin County Council to supply water to the golf course at Kilcarbery (now renamed as Grange Castle Golf Course, leased to Synergy for private operation). It created problems when drilled since sulphur is a bit like carbon. It can exist in different forms (allotropes). One type seems to be an impure plastic form, called 'Beta sulphur' or plastic sulphur. It is pure elemental sulphur, and it came out of this borehole like little strings or filaments of pale yellow-white chewing gum. It was caught in a fine net under the outfall in the tank from the rising main pipe from the borehole. Water poured from the pipe and the net caught stringy bits of 'stuff'. The problem for the golf course was that they had to empty the net at frequent intervals. A newer well was bored at a later time which provides the main water supply at present, with a storage tank at the southwest end of the course.

Present management of the course were unaware of the history of this well, and it appears to have been capped with concrete and become disused (pers. comm. David Ball). Whilst there was certainly an important scientific interest when it was drilled, it being one of only two boreholes known to have exhibited the plastic sulphur, it appears that little demonstrable interest survives.

M50/N4 interchange road sections

Following the M50 Upgrade Scheme, the M50/N4 Junction 7 (Palmerstown) interchange was modified with the result that sections of the Carboniferous Calp limestone exposures alongside the motorway were obscured, and also new exposures revealed. The best exposures now occur on the N4/M50 southbound ramp, and on the east side of the southbound lane as far as the Palmerstown Cemetery fence. According to NRA traffic statistics, over 80,000 vehicles pass the M50/N4 interchange every day (both directions). In doing so, motorists and passengers get a swift glimpse of the Calp limestone strata that underlies this - and much of, County Dublin. The IGH Master Site List records the M50/N4 interchange road sections as a *Lower Carboniferous (IGH8)* theme site for Calp limestone exposures. However, as pedestrian access to the site is not possible, as the exposures are amid a spaghetti junction of motorways, motorway slip roads, and overpasses, the site is not deemed to be of significant value as a County Geological Site. Easier and safer access to the same rock types is possible at the Liffey Valley Centre approach road, which itself is a County Geological Site (Liffey Valley Centre road sections; IGH Theme 8 – Lower Carboniferous).

Appendix 5



A detailed geological map of South Dublin County.

Appendix 6 - Geoschol leaflet on the geology of all of County Dublin

DUBLIN

AREA OF COUNTY: 921 square kilometres or 356 square miles

COUNTY TOWN: Dublin

OTHER TOWNS: Balbriggan, Dun Laoghaire, Lucan, Malahide, Rush, Skerries, Swords

GEOLOGY HIGHLIGHTS: Howth Head quartzites, Granite mountains, volcanic rocks at Portrane and Lambay, Carboniferous limestone along north Dublin coast, Killiney metamorphic rocks and glacial deposits

AGE OF ROCKS: Cambrian to Carboniferous; Quaternary

Folded Carboniferous limestone at Loughshinney, north County Dublin

These limestones were folded into tight folds during a period of mountain-building when Africa collided with Europe.

Geological Map of County Dublin

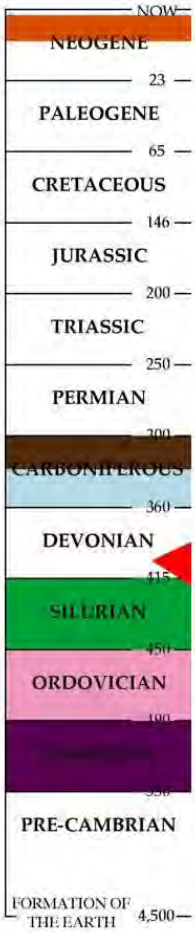
Purple: Cambrian; **Pink:** Ordovician & Silurian; **Green:** Silurian; **Dark blue:** Ordovician volcanic rocks; **Light blue:** Lower Carboniferous limestone; **Brown:** Upper Carboniferous shales; **Red:** Granite.

Geological history

The oldest rocks in Dublin occur on Howth Head where Cambrian shales and quartzites crop out. These were deposited in an ocean 500 million years ago [Ma] that separated two continents. It slowly closed so that during the Ordovician period (490-450 Ma) the crust was unstable and volcanoes began to erupt at what is now Portrane and Lambay producing a distinctive green flecky rock called Andesite. These rocks were deposited in a shallow ocean than contained many organisms including corals and trilobites. Later during the Devonian period (405 Ma) further disruption caused the granite of the Dublin mountains to be injected deep within the surface crust. As it did so it baked the rocks through which it moved and metamorphosed them into schist which can be seen at Killiney. The molten granite magma slowly cooled and formed the pale rocks that were once used as a building material in the city. Some muddy sediments were deposited in the Silurian sea, but any

Ordovician limestones form the cliffs at Portrane while a range of other rocks types are found on Lambay Island.

Devonian rocks have now been eroded away. During the Lower Carboniferous the area was covered by a warm shallow tropical seas where corals, crinoids, brachiopods, lived. Later rivers carried muds and sands that overlie the limestone in north Co. Dublin. During the Ice Age a glacier flowed down the Irish Sea and carried rocks from Scotland including a distinctive bluish microgranite from Ailsa Craig, and this ice met with ice flowing from the Irish Midlands. When it melted it deposited glacial till or boulder clay which is well-exposed along Killiney beach.



Geological timescale showing age of rocks in Dublin.

Dublin fossils

The oldest fossils from Dublin are those contained in the Cambrian slates and shales on Howth Head - there are no shells to be seen, instead only the traces and burrows preserved in the rocks. These are called trace fossils, and include *Pucksia machenri*. The Ordovician limestones at Portrane contain many fossil corals and brachiopods preserved in silica (glass) and geologists have extracted them by dissolving away the limestone that surrounds them. On the coast at Malahide and Portmarnock fossils of crinoids, brachiopods and bryozoans can be seen in the black Carboniferous limestones. In the mid-1800s a large number of skeletons of Giant Irish Deer (*Megaloceros giganteus*) which became extinct only 10,000 years ago were dug up from Ballybetagh Bog, close to Enniskerry, near the Wicklow border.

Mining and Building Stones

Lead mining in the 1700 and early 1800s took place in very small mines at Clontarf and Killiney. A well known mine at Ballycorus in south Dublin provided some lead, but soon ran

Christ Church Cathedral: Dublin's oldest stone building. Built in 1192 of black Calp Limestone quarried locally, imported cream-coloured Dundry Limestone and later roofed with green slates from Westmoreland, England.

out of ore. The lead smelter built on site was kept going by ore brought from Glendalough and other Wicklow mines. There was a big chimney built about 1.5 km away up a hill, to carry away toxic fumes. Some of the lead condensed on the inside of the tunnel and was collected every few months. The chimney has lost the brick top but is still a well known landmark.

Over 100 different stone types have been used for buildings in Dublin, but of these few have been quarried in the County. The most famous Dublin stone is Calp Limestone which is a black muddy limestone that was used for Christ Church Cathedral and the Old Library in Trinity College. Dalkey Quarry provided granite blocks for Dun Laoghaire pier, and many buildings used Leinster Granite from near Blessington or Limestone from Milverton near Skerries. The harbour at Dun Laoghaire is so big it shows up easily on satellite images. The rock to build it came from Dalkey Quarry and was carried down by a small railway. Dalkey and many smaller quarries also provided the granite building stone seen all over Dublin in larger houses and structures. Today many buildings are constructed of concrete or blocks which is produced from Carboniferous limestone quarried at Feltrim and Belgard near Clondalkin.

Geology museums and information

- Geological Museum, Trinity College, Dublin 2 (wysjcknp@tcd.ie); National Museum of Ireland (www.museum.ie); Geological Survey of Ireland (www.gsi.ie)

Suggested reading

- Patrick Wyse Jackson: *The Building Stones of Dublin* (1993) Country House.
- Patrick Wyse Jackson and others: *Field Guide to the Geology of some localities in County Dublin* (1993) TCD & ENFO.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003.
Image credits: Mike Simms 1; Matthew Parkes 3; Patrick Wyse Jackson 4.

www.geoschol.com
Text by Patrick Wyse Jackson & Matthew Parkes

Section 2 - Site Reports

Site reports – general points
The following site reports are brief non-technical summaries of the proposed County Geological Sites for South Dublin County. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports and information files are held in the IGH Programme in the Geological Survey of Ireland. These are available for consultation if required. Further sites may become relevant as IGH Programme work develops.

Each site report has primary location information, a mention of the main rock types and their age, and a short description of the key aspects of scientific interest. A section outlining any particular management or other issues specific to the site is included, along with one or two low resolution photographs exemplifying the site. **A CD accompanying this report will include further pictures of most sites at higher resolution, should they be required for a glossy booklet or leaflet for the general public**. Grid references are given for a central point in the site generated from the GIS mapping (a shapefile) of the site boundary. They are only indicative of the location, but the site extent is best shown on the included maps.

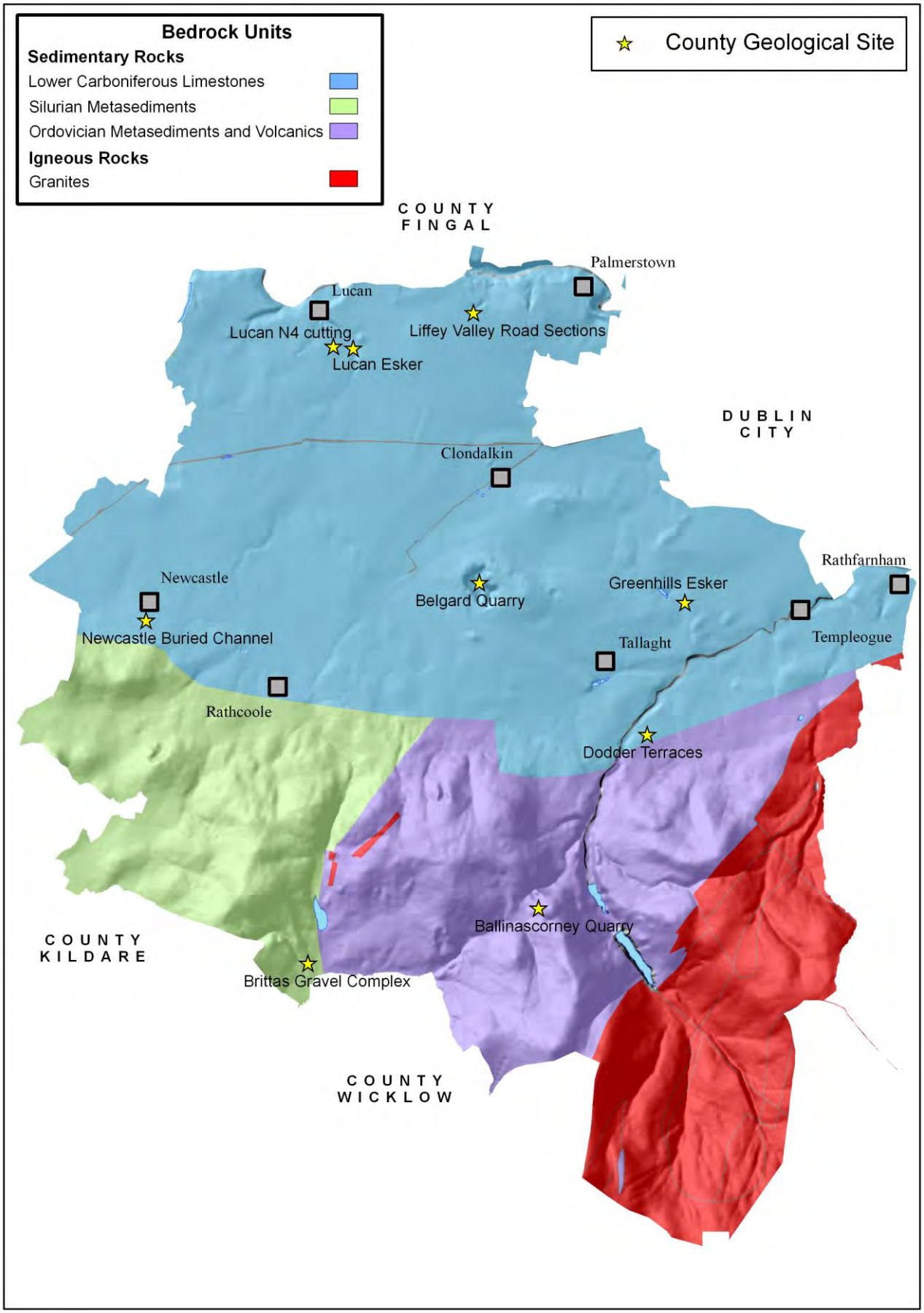
Irish Transverse Mercator (ITM) is the geographic projection co-ordinate system now in use for Ireland, and has been applied to all site localities in the site reports. It is the standard co-ordinate system for OSi maps, including the new Discovery map series, but a coordinate conversion tool is available on the OSi website at:
http://www.osi.ie/calculators/converter_index.asp?alias=/services/gps-services/co-ordinate-converter#results.

A series of maps are provided with an outline of the site boundary. It is important to note that these boundaries have no legal or definitive basis. They are indicative only of the limits of exposure or of geological interest, and not based on detailed field and boundary surveys, which were outside the scope of this contract. Boundaries are drawn to include the geological or geomorphological interest of the site, but are extended to the nearest mappable boundary, such as a field boundary, stream, road or edge of forestry. On a few sites, such as in open mountain terrain, it is impractical to find a boundary within a reasonable distance and an arbitrary line may be defined. County Geological Sites are non-statutory and so this is not problematic. If any such site is fully assessed for NHA status in the future, such a boundary may require small revisions.

For sites that have been recommended or which will be recommended for NHA designation detailed site boundary maps will become available to the Local Authority, through NPWS as the designation process is undertaken. Some areas may already be available if they are proposed NHAs (pNHA), under the Wildlife (Amendment) Act 2000. Areas which have been designated as Special Areas of Conservation (SAC) under European Habitats Directives will also have statutory boundaries already determined. The geological interest may be included within these wider areas of nature conservation.

In terms of any geological heritage site designation as NHA, due process of site reporting, boundary survey and very importantly, consultation with landowners where they can be readily identified, will take place before GSI finalises

recommendations with NPWS on the most important sites to be designated. Any landowner within areas or sites identified in this report with concerns over any aspect of this project is encouraged to contact Sarah Gatley, Head of the Heritage and Planning Programme, in the Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4. Phone 01-6782837. Email: sarah.gatley@gsi.ie



Simplified Geological Map of South Dublin County with site locations indicated.

SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Brittas Gravel Complex**
Other names used for site	Includes both the 'Brittas Moraine' and 'Ballinascorney-Aghfarrell Delta'
IGH THEME	**IGH7 Quaternary**
TOWNLAND(S)	**Calliaghstown Upper, Slievethoul, Slademore, Crockaunadreenagh, Brittas Little, Brittas Big, Glenaraneen, Lugg, Raheen, Gortlum, Mountseskin, Aghfarrell, Ballinascorney Upper**
NEAREST TOWN/VILLAGE	**Brittas**
SIX INCH MAP NUMBER	**24**
ITM CO-ORDINATE	**703025E 721400N (centre of feature)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
The Brittas Gravel Complex includes a large accumulation of sands and gravels deposited at the edge of a series of ice margins at the end of the last Ice Age.

Geological System/Age and Primary Rock Type
The meltwater complex formed on bedrock of Ordovician and Silurian metasediments and volcanic rocks, but the features comprising the complex itself are Quaternary in age.

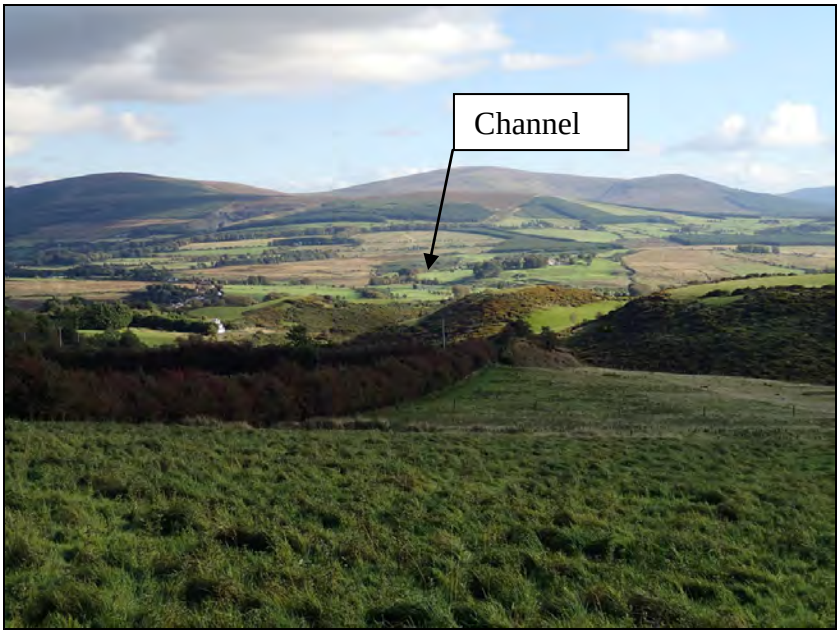
Main Geological or Geomorphological Interest
The meltwater complex includes a distinctive hummocky and scalloped topography around Brittas and on the flanks of the surrounding, high bedrock ridges, where the land surface is formed of many small ridges, hummocks, swales, channels and marked hollows.

The feature is poorly exposed today but in the 1950s Anthony Farrington of the Geological Survey of Ireland logged many gravel pits from the area in detail, as well as mapping the topography of the area. The topography reflects a wide range of depositional settings that resulted in ice-pushed moraine ridges, meltwater channels and ice marginal fans. Farrington suggested that the meltwater complex was formed during two major glacial incursions from the Irish Midlands onto the Dublin/Wicklow Mountains, and an intervening advance of a mountain ice cap onto the lowlands. This scheme was based on the relative position of moraine ridges in the valleys around Brittas and along the margins of the mountain ice mass.

The meltwater complex has some still puzzling elements, including a large deltaic deposit at Aghfarrell which is composed of limestone gravels resting on granite gravels. Several hypotheses have been put forward for the formation of such a feature. As well as this, the exact sequence of ice withdrawal and related meltwater deposition has never been researched and mapped in detail.

Site Importance – County Geological Site
The feature is a good example of the haphazard, hummocky topography which forms at the retreating margin of a melting ice sheet at the edge of an upland area. The central portion of the feature forms part of the proposed NHA (SAC 000211, Slade of Saggart and Crooksling Glen), for biodiversity reasons, and the geodiversity of the meltwater complex should be highlighted in any promotion of this.

Management/promotion issues
This system comprises a fine landform sequence and should be listed as a County Geological Site. The hummocks and related features are best seen on a drive from Ballinascorney to Brittas, along the R114 road.

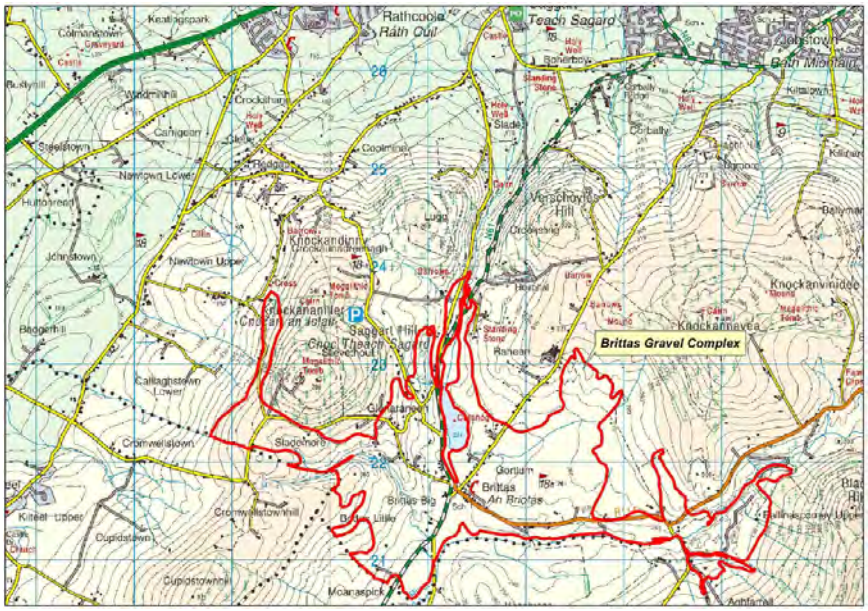


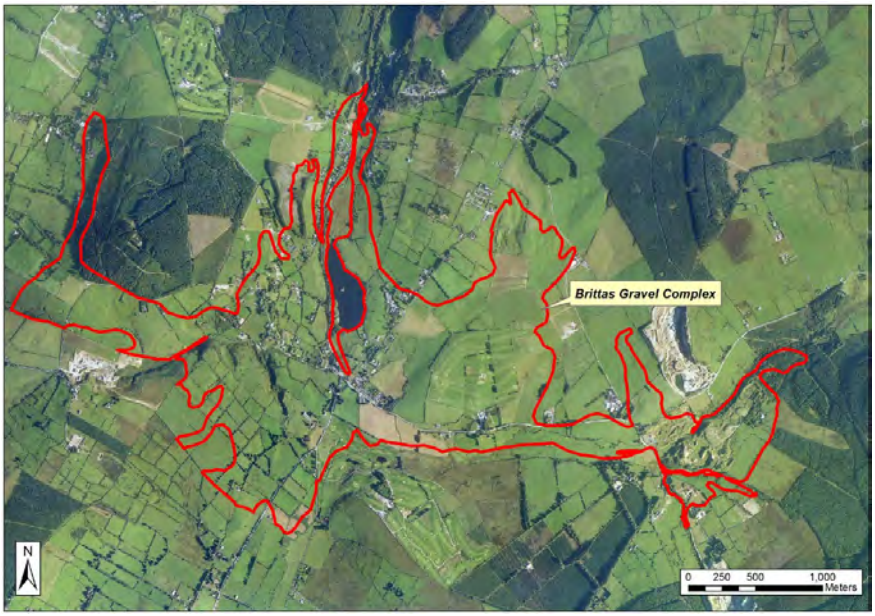
Meltwater channels in haphazard topography at Slademore, just west of Brittas.

Scalloped landscape on the southern slopes of Saggart Hill, in Slademore.

A shallow channel among hummocks of sands and gravels at Slademore.

A flat-topped delta feature at Brittas Little, in the central portion of the meltwater complex.


Brittas Gravel Complex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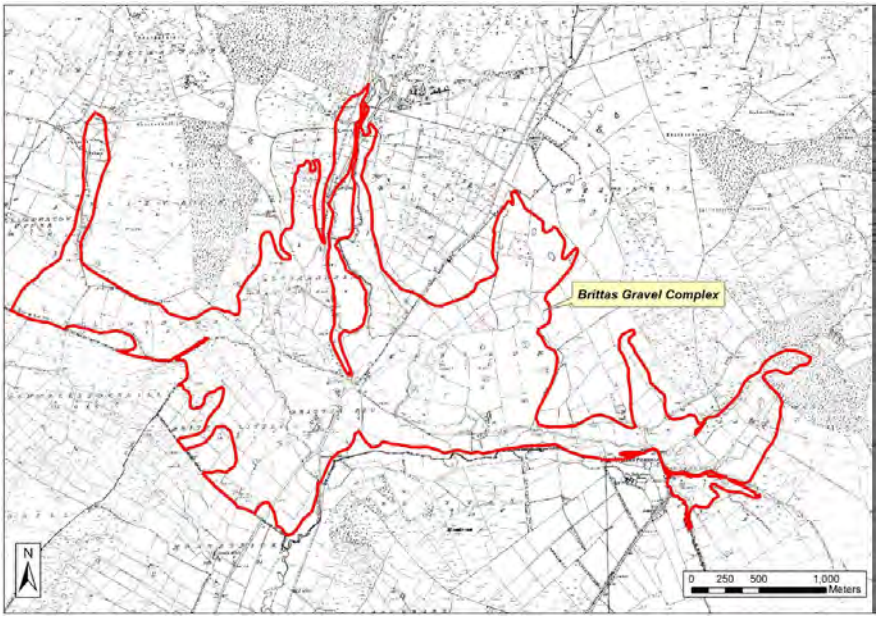
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SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Dodder Terraces**
Other names used for site	
IGH THEME	**IGH7 Quaternary**
TOWNLAND(S)	**Kiltipper, Ballymace, Friarstown Upper, Bohernabreena, Killininny, Tallaght, Tymon South, Knocklyon, Templeogue, Oldbawn**
NEAREST TOWN/VILLAGE	**Tallaght**
SIX INCH MAP NUMBER	**21, 22, 24, 25**
ITM CO-ORDINATES	**709960E 726430N (centre of Dodder channel at Oldbawn)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
The Dodder Terraces comprise a series of flat-topped, elevated terraces much higher than the current Dodder River, but which form what was the river floodplain during the last deglaciation at the end of the last ice Age.

Geological System/Age and Primary Rock Type
The Dodder channel is formed in an area of glacial till of varying depths, with portions of bedrock outcrop or subcrop along its stretch. The till was deposited at the maximum of the last Ice Age. The terraces on either side of the channel were formed during deglaciation at the end of the last Ice Age, by meltwater deposition along the edge of the deglacial Dodder River.

The bedrock in the locality is varied, with Ordovician metasediments underlying most of the high ground south of Bohernabreena, and bedded 'Calp' limestone in the northern, lowland portion.

Main Geological or Geomorphological Interest
The sand and gravel terraces of the Dodder River record the deglacial retreat of the ice sheet through south Dublin at the end of the last glaciation. Well-defined suites of glaciofluvial and delta terraces occur along the valley between Ballinacroeny Lower and Templeogue. They are linear forms and are generally subparallel to the meanders of the river, though some of the highest examples at Kiltipper are isolated fragments.

All of these deposits are genetically related to the deglaciation of a prominent valley and its subsequent dissection by extraglacial meltwaters. The terraces are dominated by sands and gravels derived from Lower Carboniferous limestone. Their well drained nature means they generally form productive grassland.

Site Importance – County Geological Site
This is a location with good potential as a teaching site on glacial meltwater deposition, as the feature is accessible and easily viewed from both the R114 road at Bohernabreena and the N81 at Templeogue-Tallaght. The terraces now form the 'green' parkland beside the river in these latter localities.

Management/promotion issues
The roadside location of the feature means it is easily accessible, and the parks and walkways between Tallaght and Templeogue along the river mean the terraces form an active part of the recreational lifestyle in this area. Parking is available and a signboard in the park near Oldbawn Bridge, outlining the formation of the terraces and the deglacial Dodder channel, as well as the bedrock geology of the locality, may help promote the features.

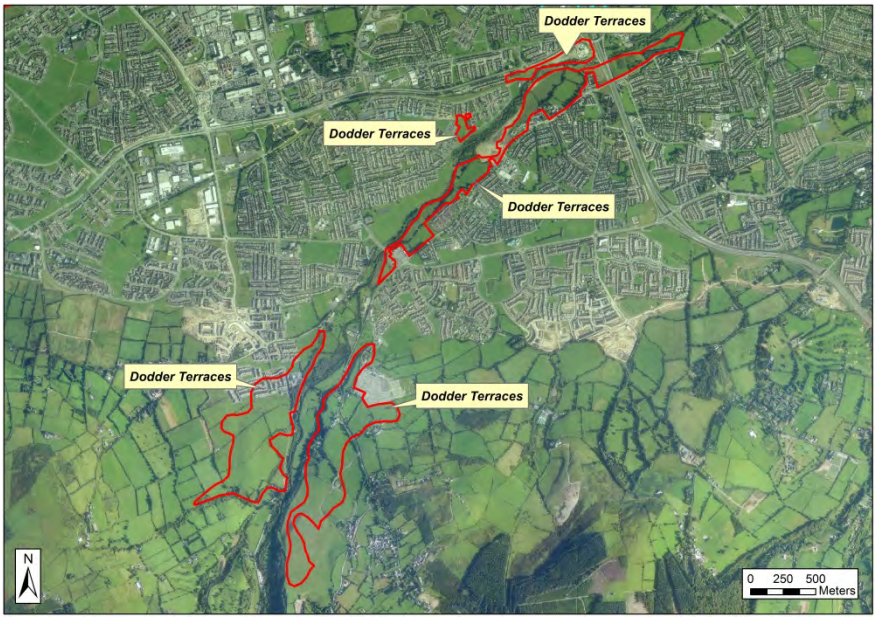
The former floodplain level of the Dodder during deglaciation is clearly seen here at Tallaght.

Also at Tallaght, the Dodder channel, with gravel islets forming in the modern day river.

Part of the terraces in the public parkland at Oldbawn, adjacent to Oldbawn Bridge.

Part of the flat-topped terrace at Bohernabreena, beside the N81 road.


Dodder Terraces
Dodder Terraces
Dodder Terraces
Dodder Terraces
Dodder Terraces
Tallaght
Tamhlacht
Knocklyon
Ballyboden
Bailebaodain
Edmondsto
Oldcount
Woodtown
Newtown
Rockbrook
Orlagh
Jamestown
Friarstown
Cerragreen
Ballinascorney Lower
Megalithic Tomb
Standing Stone
Church
Holy Well
M50
R115
R113
R116
N81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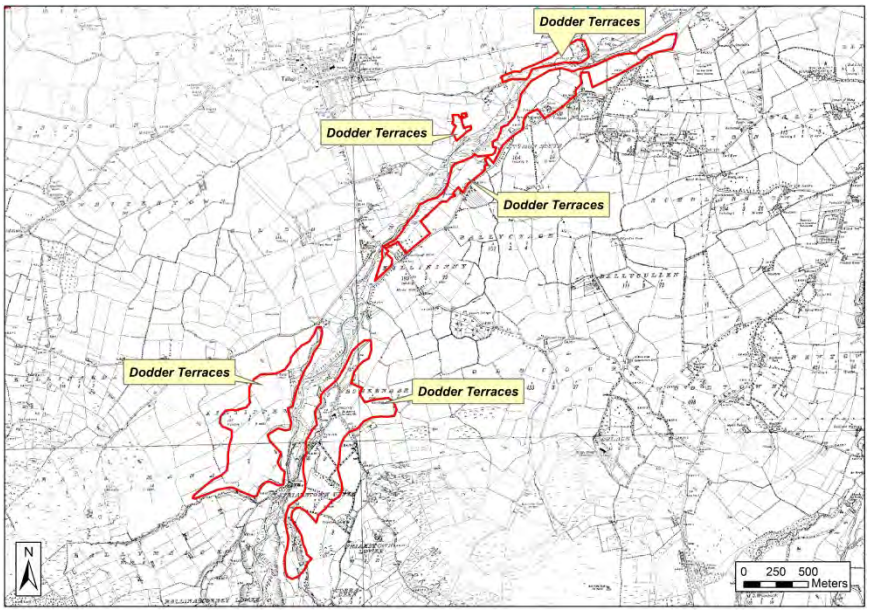
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SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Greenhills Esker**
Other names used for site	The Green Hills Esker
IGH THEME	**IGH7 Quaternary**
TOWNLAND(S)	**Kilnamanagh, Tymon North**
NEAREST TOWN/VILLAGE	**Templeogue**
SIX INCH MAP NUMBER	**22**
ITM CO-ORDINATES	**710514E 729108N (centre of feature)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
The Greenhills Esker includes a large accumulation of sands and gravels deposited both under the ice sheet and at its margin as the ice withdrew northwestwards across south Dublin at the end of the last Ice Age.

Geological System/Age and Primary Rock Type
The Greenhills Esker is formed within an area of Lower Carboniferous limestone, but the esker itself is Quaternary in age, having been deposited either under or at the edge of the northwestward-retreating ice sheet during deglaciation after the last Ice Age.

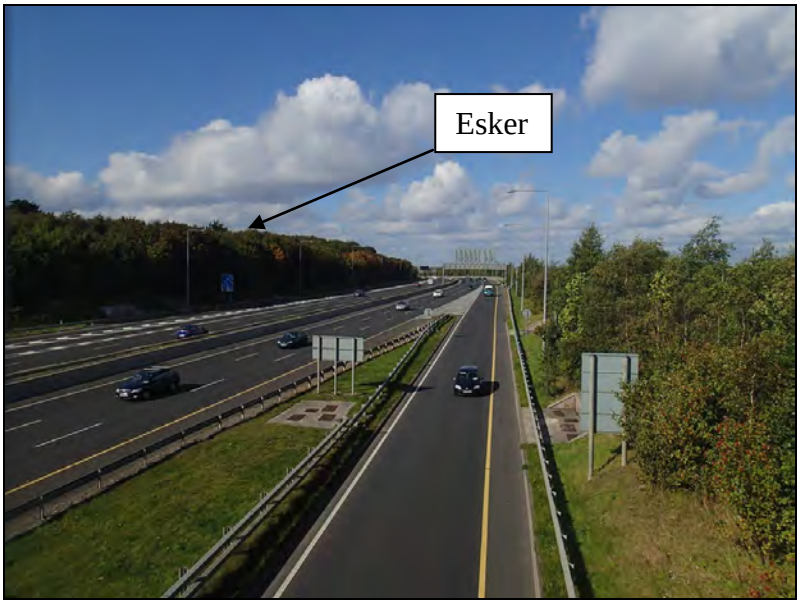
Main Geological or Geomorphological Interest
Much of the esker itself has been removed by historical quarrying of its constituent sands and gravels, so only fragments of the feature remain intact. Where present, the esker ridge is a striking feature, standing proud of the flat landscape of till (boulder clay) upon which it was deposited. Intact portions adjacent to Tymon Lane and adjacent to the M50 are especially impressive. Here the esker is comprised of a raised, elevated ridge of sands and gravels.

The feature is also important in a historical and cultural sense as Greenhills itself is named after the sand hills that formed the esker. These have since been quarried away but many of them can be seen on the historical six inch sheets of the locality. The siting of Tymon Castle, now in ruins and nowadays the site of Tymon Park's Ranger Station, was purposely on top of one of the esker's highest hills, depicted beautifully in an eighteenth century painting by Gabriel Beranger.

The esker feature is important in that it records faithfully the ice movement across this area of Dublin, which is along its orientation, *i.e*. northwest to southeast. Associated sands and gravels along the Greenhills Road, northeast of the esker are probably part of an associated ice marginal fan. The sands and gravels within the feature are comprised chiefly of limestone clasts.

Site Importance – County Geological Site
What remains of the feature is still a striking example of a high, dry sand and gravel ridge that stands proud of the surrounding landscape. This esker and the associated sands and gravels along the Greenhills Road seem to be a good example of a deglacial, meltwater-deposited complex, with portions deposited under the ice, and portions at the ice margin.

Management/promotion issues
This system comprises a well-defined landform sequence and should be listed as a County Geological Site. A signboard within Tymon Park, where the feature can be well seen and where there are already several signboards, might help promote the feature.



The Greenhills Esker covered in broadleaved woodland, alongside the M50 Motorway at Tymon North.

Some of the landscaped portion of the extant Greenhills Esker ridge, in Tymon Park just north of the Ranger Station.

A wooded portion of the esker near the National Basketball Arena.

Walks through and alongside the esker in the northeastern portion of Tymon Park.


An Cleigin Gorm
Fox & Geese
Walkinstown
Baile Bhailcin
Grenlin
Stronghlinn
Kimmage
Camaigh
Newlands
Kingswood
Greenhills
Na Glasóhaidc
Greenhills Esker
Cill na Manach
Tymon North
Tigh Mothain Thuaidh
Templeogue
Teach Meallog
Willbrook
Tallaght
Tamhlachta
Knocklyon
Ballyboden
Baile Bodain
Firhouse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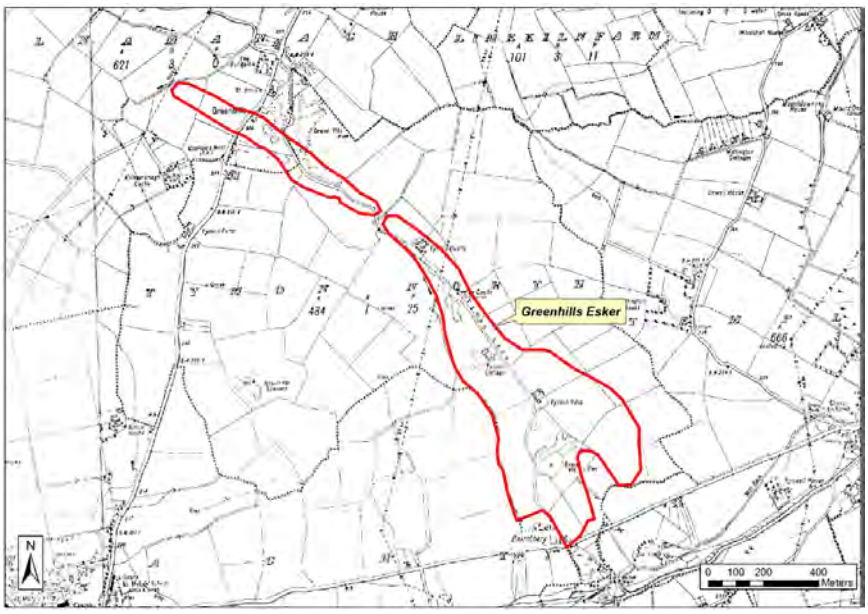
Greenhills Esker
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Meters

Tymon Castle, which sat on a portion of the esker, depicted in the painting of the castle by Gabriel Beranger in the eighteenth century.

SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Kippure**
Other names used for site	*Cipiúr*
IGH THEME	**IGH7 Quaternary, IGH14 Fluvial/Lacustrine Geomorphology**
TOWNLAND(S)	**Powerscourt Mountain, Kippure, Castlekelly**
NEAREST TOWN/VILLAGE	**Enniskerry**
SIX INCH MAP NUMBER	**27**
ITM CO-ORDINATES	**711500E 715490N (summit)**
1:50,000 O.S. SHEET NUMBER	**56 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
A landmark mountain on the South Dublin-Wicklow county boundary, capped with a prominent transmission tower. The upper mountain hosts extensively eroded peat, exposed granite sands, and granite blocks.

Geological System/Age and Primary Rock Type
Erosion of the peat has been ongoing for the past 3,000 years on this granite mountain. The granites (fine to coarse-grained, with microcline phenocrysts) are part of the Late Caledonian Leinster granites that were emplaced around 405 million years ago (Devonian).

Main Geological or Geomorphological Interest
Above heights of c. 740m, the near-flat summit of Kippure is devoid of significant peat accumulations. The summit hosts a blockfield of rounded granite boulders that lie embedded in grus (crumbled sandy granite). Below the 740m contour, areas of blanket peat are extensively eroded. Deep peat gullies, sub-peat pipes, solitary peat hags, and collapsing peat banks characterize much of the upper mountain slopes. Where peat has eroded fully, granite bedrock is exposed, with thick accumulations of grus, or granite sand (quartz, feldspar, mica) overlying the bedrock.

Peat erosion has been a continual process in the Dublin and Wicklow Mountains for over 3,000 years, and is not considered to be attributed solely to recent human disturbance. Peat erosion is considered to be a natural consequence of the accumulation of peat on sloping ground. Climate is also considered to be an influencing factor, as are natural blog flows. Clearance of woodlands in the region pre-dates the onset of peat erosion by too significant a period of time to have had any direct influence on the onset of erosion. Human and biotic factors (grazing animals, vegetation burning, drainage, trampling) are both considered contributory factors to peat erosion, although studies indicate that erosion began before most human and biotic factors began.

Site Importance - County Geological Site
This site is an excellent CGS for observing the effects of long-term (millennial scale) peat erosion. Kippure is a landmark mountain, and is the most northerly of the nunataks in the Wicklow Mountains. The site is located in the Wicklow Mountains SAC (02122) and should be considered along with the adjacent part of Kippure CGS in County Wicklow.

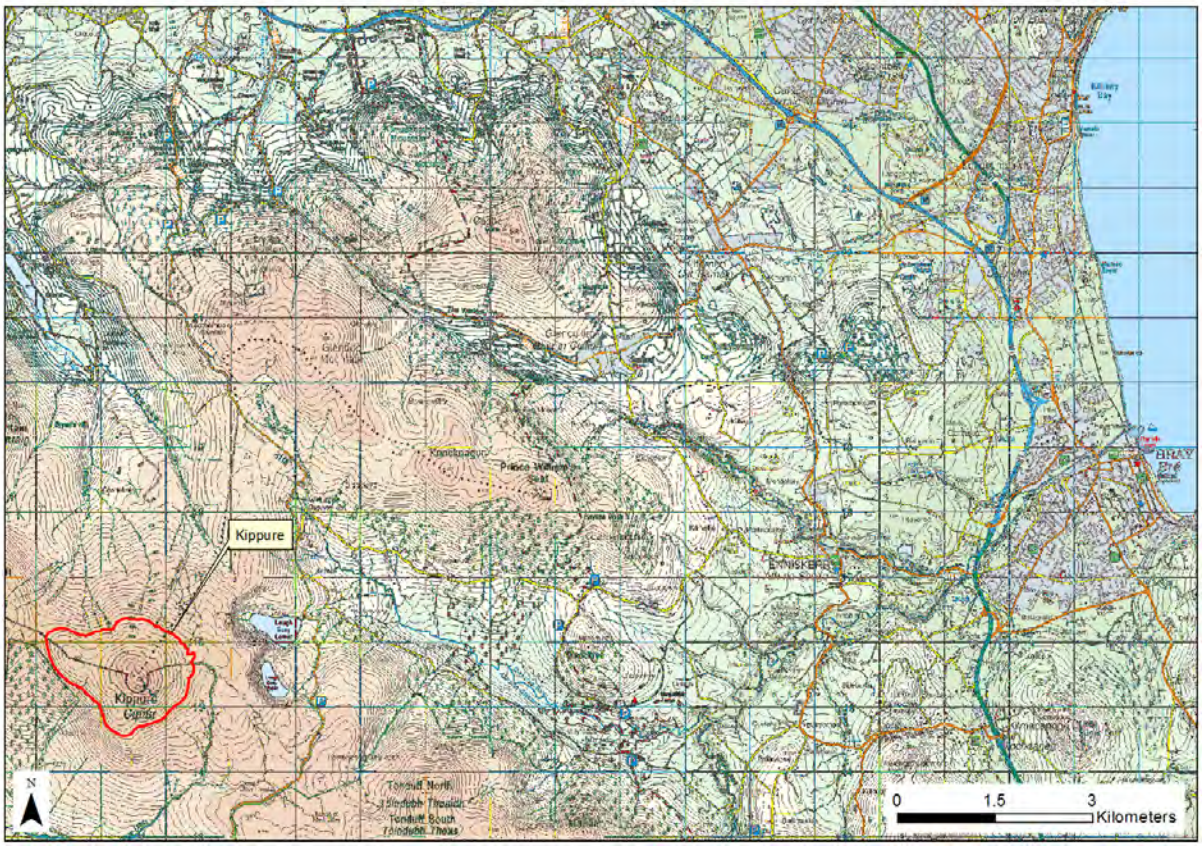
Management/promotion issues
Access to the site by foot is afforded along a 3.5km tarmacadam service road. The summit is capped by a 127m high TV and radio transmitter mast. It has been suggested that management of the peatland resources may decrease current erosion rates in some areas of high-level blanket peat. The processes of peat erosion that are evident on Kippure and elsewhere in the Dublin and Wicklow Mountains are an integral part of any upland blanket peatland system.

Upper limit of peat erosion on east side of Kippure summit. Main erosion occurs below this altitude (~740m).

Peat banks, peat hags, granite sands and granite blockfields on Kippure summit, looking north towards Tallaght

Sub-peat pipes and gullies on upper east slopes.

RTÉ radio/TV transmitter station on summit.


Kippure
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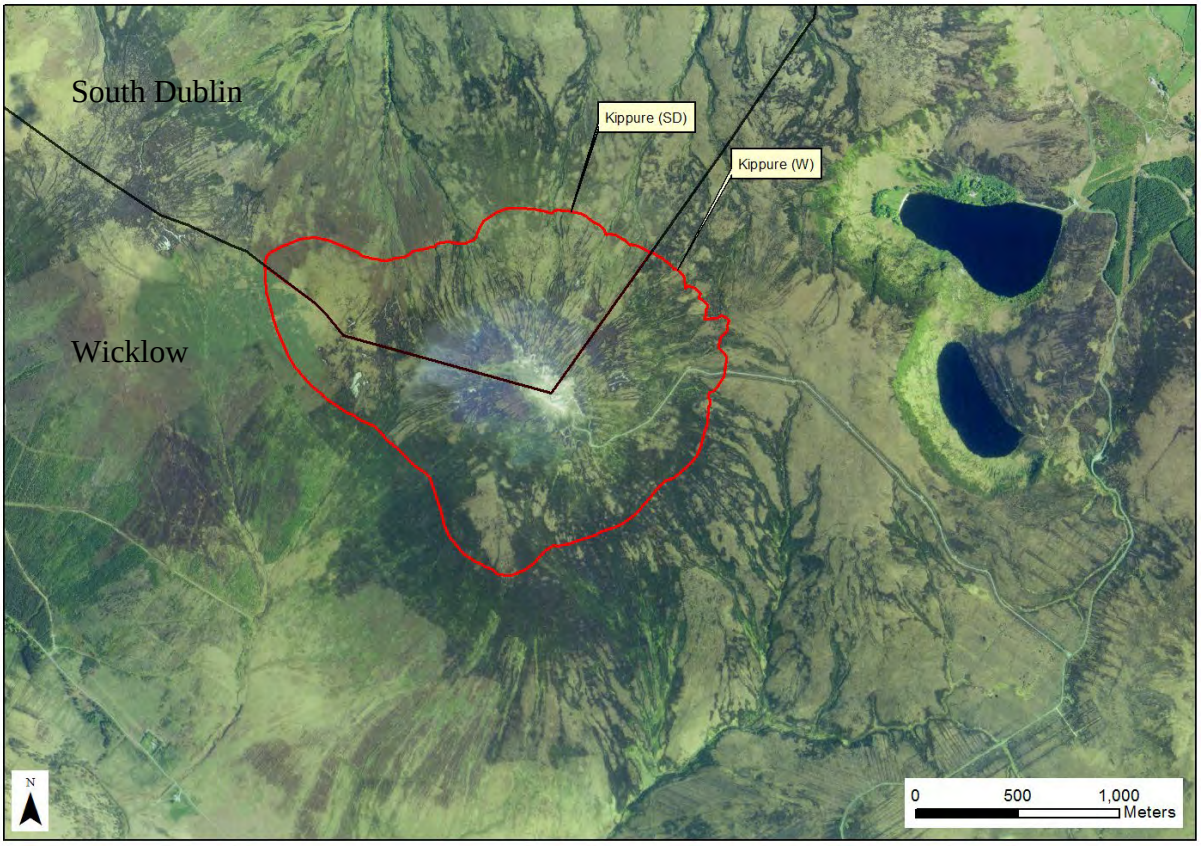
Kilometers


South Dublin
Kippure (SD)
Kippure (W)
Wicklow
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SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Lucan Esker**
Other names used for site	Also part of the *'Slí Mhór',* or *'Eiscir Riada'*
IGH THEME	**IGH7 Quaternary**
TOWNLAND(S)	**Lucan and Pettycanon, Esker South**
NEAREST TOWN/VILLAGE	**Lucan**
SIX INCH MAP NUMBER	**17**
ITM CO-ORDINATES	**703500E 734630N (centre of feature)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
The Lucan Esker includes a large accumulation of sands and gravels deposited both under the ice sheet and at its margin as the ice withdrew northwestwards across west Dublin at the end of the last Ice Age.

Geological System/Age and Primary Rock Type
The Lucan Esker is formed within an area of Lower Carboniferous limestone, but the esker itself is Quaternary in age, having been deposited either under or at the edge of the northwestward-retreating ice sheet during deglaciation after the last Ice Age.

Main Geological or Geomorphological Interest
Much of the esker itself has been removed by historical quarrying of its constituent sands and gravels, so only fragments of the feature remain intact. Where present the esker ridge is a striking feature, standing proud of the flat landscape of till (boulder clay) upon which it was deposited. Intact portions adjacent to Esker Glebe in Griffeen Valley Park, and at Vesey Estate near the Griffeen River, are especially impressive. Both localities are comprised of raised, elevated areas of sands and gravels, which might look upon first inspection to be mounds of artificially-landscaped ground, but are in fact steep, winding slopes of the original delta form.

The feature is also important in a historical and cultural sense in Lucan, as the townlands of Esker North and Esker South, as well as Esker House, Esker Bridge, Esker Cottage and Esker Cemetery, were all named after the feature. Several modern-day estates, such as Esker Glebe, and the main arterial route Esker Road, have followed suit, and St. Patrick's Parish church at Lucan is called Esker Church. Griffeen Road, oriented northwest to southeast, sits atop the original esker feature.

The esker feature is important in that it records faithfully the ice movement across this area of West Dublin, which is along its orientation, *i.e*. northwest to southeast. The sands and gravels within the feature are comprised chiefly of limestone clasts.

Site Importance – County Geological Site
What remains of the feature is still a striking example of a high, dry sand and gravel ridge that stands proud of the surrounding landscape. This is a good example of a deglacial, meltwater-deposited feature, with portions deposited under the ice, and portions at the ice margin.

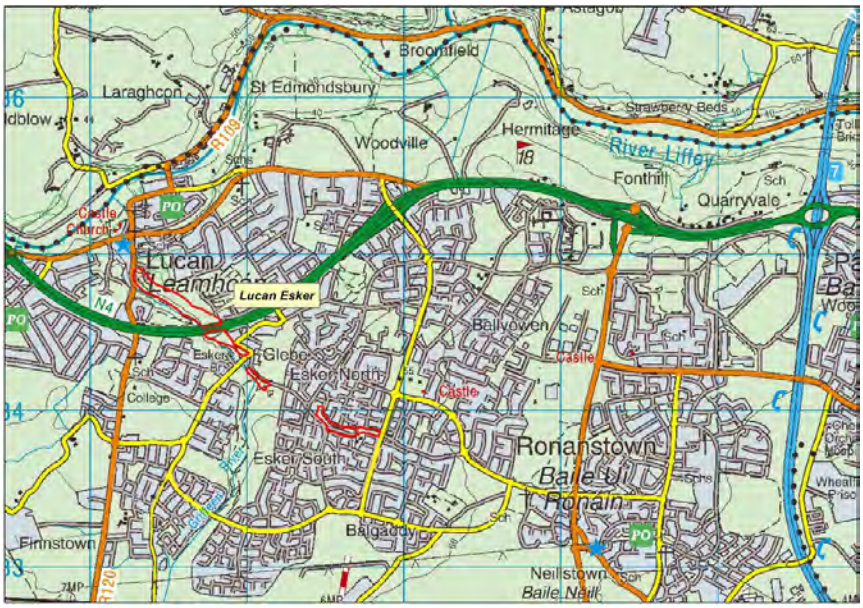
Management/promotion issues
This system comprises a well-defined landform sequence and should be listed as a County Geological Site. A signboard within Griffeen Valley Park, where the feature can be well seen and where there are already several signboards, might help promote the feature. In this, the naming of several sites in the area after the esker is important to mention.

Broadleaved Woodland on the Lucan Esker in Griffeen Valley Park.

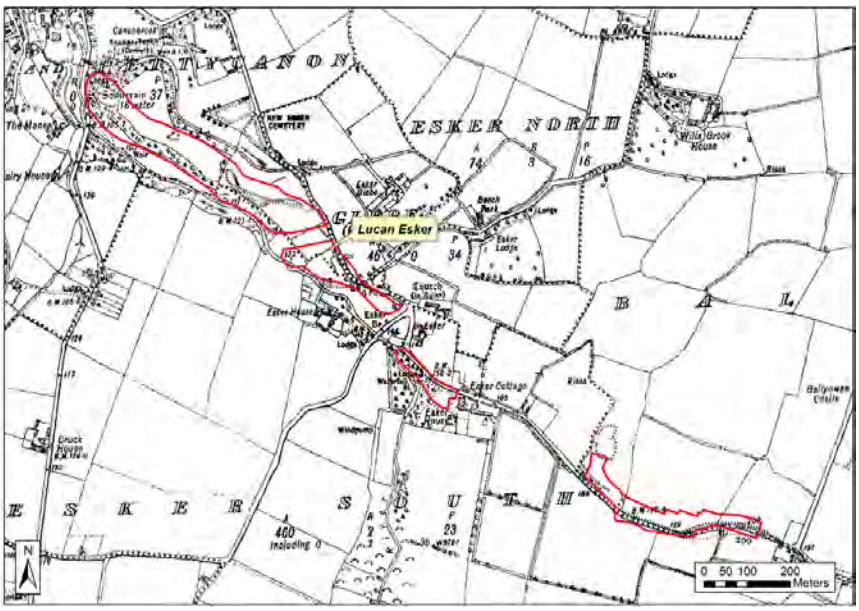
Some of the winding portion of the extant Lucan Esker ridge, beside the Esker Glebe estate, and just south of the M4.

View northwest along the steep-sided Lucan Esker in Griffeen Valley Park.

Many of the placenames in the Lucan locality are ‘Esker’ derivatives.


Broomfield
Laraghcon
St Edmondsbury
Strawberry Beds
Hermitage
Woodville
River Liffey
Fonthill
Quarryvale
Castle Church
Lucan
Lucan Esker
Ballyowen
Esker
Esker North
Castle
College
Ronanstown
Esker South
Finnstown
Balgaddy
Neilstown


Lucan Esker
N
0 50 100 200
Meters


ESKER NORTH
Lucan Esker
ESKER SOUTH
N
0 50 100 200
Meters

SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Belgard Quarry**
Other names used for site	
IGH THEME	**IGH 8 Lower Carboniferous, IGH 15 Economic Geology**
TOWNLAND(S)	**Cheeverstown, Belgard, Bedlesshill, Kingswood**
NEAREST TOWN/VILLAGE	**Clondalkin**
SIX INCH MAP NUMBER	**21**
ITM CO-ORDINATES	**706400E 729100N (centre of quarry)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO: 16**

Outline Site Description
Belgard Quarry is a very large, working quarry.

Geological System/Age and Primary Rock Type
The quarry is extracting the Lower Carboniferous Limestone.

Main Geological Interest
Belgard is the largest limestone quarry in the country and is excavating the Lower Carboniferous Calp limestone. This is a deeper water basinal limestone, in regular beds of varying thickness. The extensive quarry faces show the rocks well, with gentle dips in most parts, but with some localised flexures and disruption along faulted zones, with nearly vertical beds in localised zones. There are only a couple of metres of overburden. In one section of the quarry, a particular impermeable layer has the effect of causing extensive groundwater flow out of the face, with tufa type deposits forming a curtain over the face.

Site Importance - County Geological Site
As a particularly large quarry, supplying a range of products to the large Dublin market, Belgard has a vital economic importance, but is also of geological heritage significance as the biggest exposure of the otherwise poorly exposed Calp Limestone which underlies Dublin.

Management/promotion issues
As a large, busy working quarry, there is normally no access, unless for organised visitors with permission and by prior arrangement with the quarry management. The public can however visit a retail zone where company products from this and other quarries are displayed. The quarry has reserves to last for many decades and so the end-use is not an important issue for this generation.

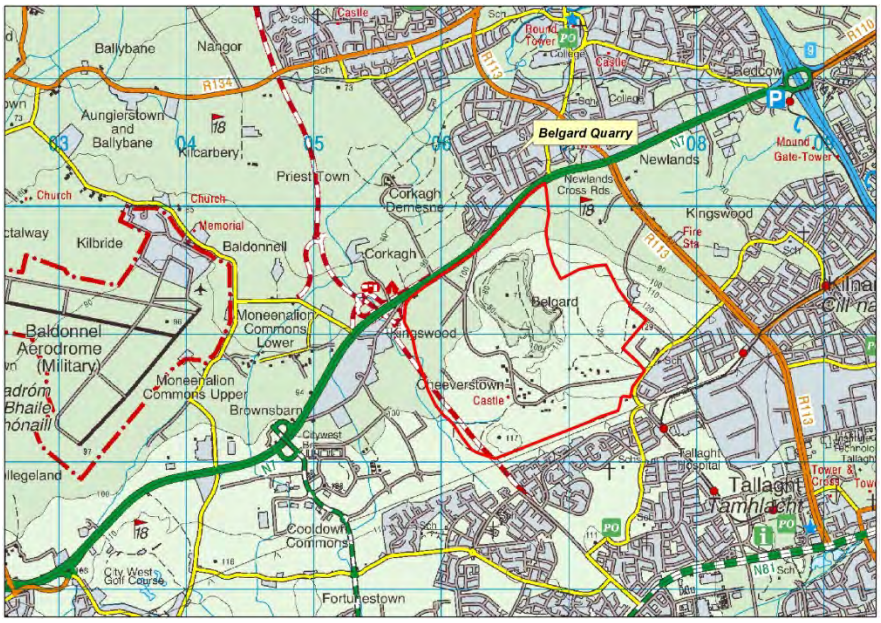
A panoramic view of Belgard Quarry from the south west side.

A panoramic view of Belgard Quarry in the deepest working in late 2014.

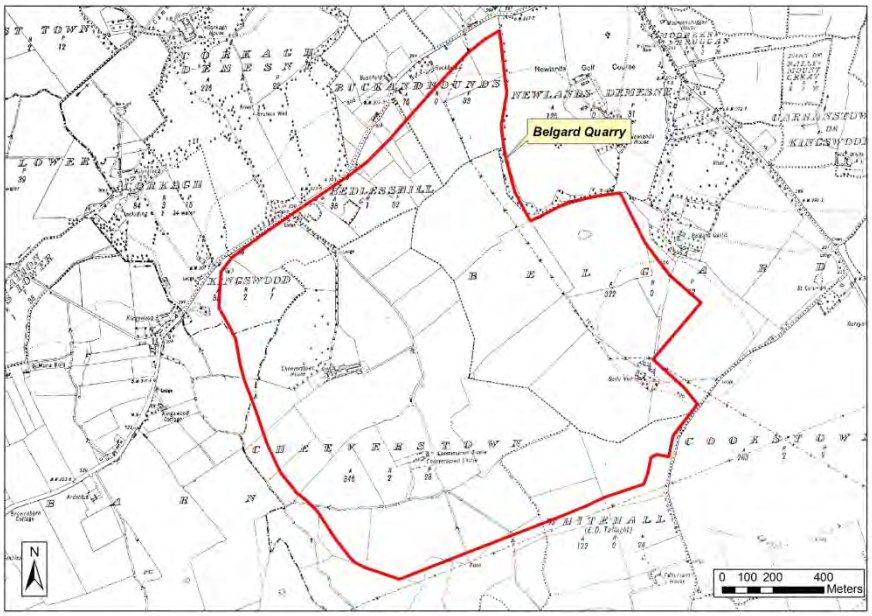
A panoramic view of Belgard Quarry on the north western side.

Tufa curtain on a face.

Disrupted beds in a fault zone.


Belgard Quarry
Ballybane
Nangor
Castle
Round Tower
College
Bledcow
Augherstown and Ballybane
Kilcarbery
Priest Town
Corkagh Demesne
Newlands
Newlands Cross Rds
Mound Gate-Tower
Kingswood
Fire Sta
Church
Memorial
Kilbride
Baldonnell
Corkagh
Belgard
Moneenalion Commons Lower
Baldonnel Aerodrome (Military)
Moneenalion Commons Upper
Brownsbarn
Citywest
Cheeverstown Castle
Tallaght Hospital
Tallaght
Cooldown Commons
City West Golf Course
Fortunestown
R134
R113
R110
N81


Belgard Quarry
N
0 100 200 400
Meters


Belgard Quarry
Newlands Golf Course
NEWLANDS DEMESNE
KINGSWOOD
BELGARD
CHEEVERSTOWN
COOKSTOWN
N
0 100 200 400
Meters

SOUTH DUBLN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Liffey Valley Centre road sections**
Other names used for site	Fonthill Road R113
IGH THEME	**IGH8 Lower Carboniferous**
TOWNLAND(S)	**Yellow Walls, Irishtown, Quarryvale**
NEAREST TOWN/VILLAGE	**Lucan**
SIX INCH MAP NUMBER	**17**
ITM CO-ORDINATES	**706350E 735130N (centre of feature)**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
Roadside exposures of Calp limestones near the N4 junction to Liffey Valley Shopping Centre.

Geological System/Age and Primary Rock Type
Bedrock consists of Lower Carboniferous (Mississippian) 'Calp' (Lucan Formation). Mainly dark grey coloured limestones interbedded with shaly limestones, and shales.

Main Geological or Geomorphological Interest
The bedrock consists of beds of dark grey-black, fine-grained limestone with interbedded calcareous shale, local cherts and fossiliferous beds. Calp bedrock underlies most of Dublin City, from Jobstown north to Santry, and from Irishtown to the west of the city, and discontinuously as far west as Athenry, Co. Galway. The calp limestone is not susceptible to karstification and no major cavities occur in these rocks. The south dipping strata (10-15°S) are exposed on each side of the R113 roundabout on the south side of the N4 (junction 2). The best exposures are on the southeast side of the roundabout. The limestone strata are typically between 100mm and 300mm thick, with thinner interbedded shale beds.

Liffey Valley Shopping Centre occupies the site of a previous quarry (known as Cursis-stream), which was in operation in the late eighteenth century, and is noted on early OSI maps (Quarryvale). According to an essay penned in 1772 by Dr. John Rutty (*Essay towards a Natural History of the County Dublin),* Cursis-stream quarry "supplied black flags for flooring, hearthstones, headstones and tombstones…[the] stones were smoothed with Wicklow sand and water". The dark-coloured calp was a traditional building stone in the Dublin area.

Site Importance: County Geological Site
This site is of special geological and historical interest. It is much more accessible than similar cuttings into the same rocks on the M50 where roads such as the N7 intersect it.

Management/promotion issues
Owing to the high-level of traffic at this roundabout and stretch of road (R134) by the Liffey Valley Shopping Centre, this is one of the most recognised sites exposing a section through the limestone strata that underlies much of this part of County Dublin. The site is ideally suited for inclusion in any promotional and education material relating to the geological history and heritage of Dublin.

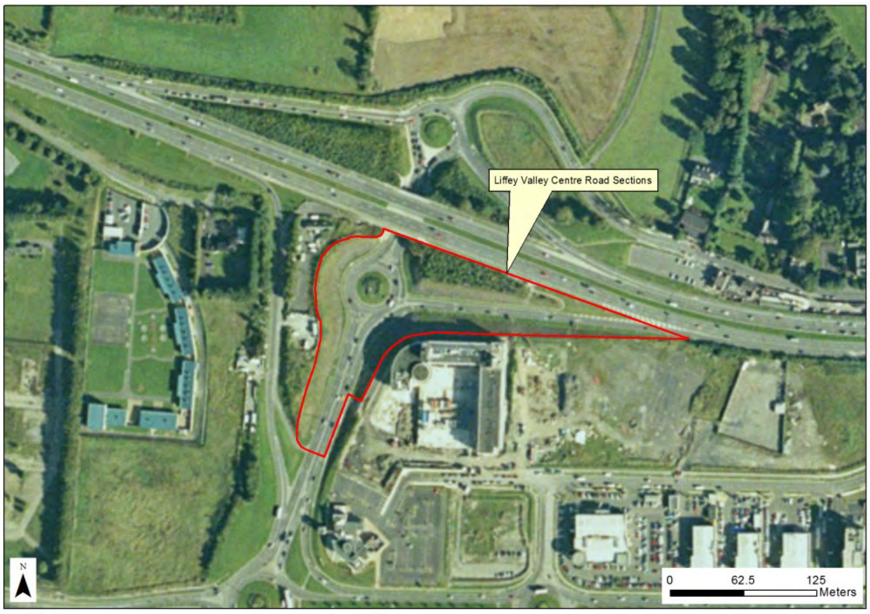
View eastwards to N4 (west) down-ramp from Fonthill Road. Calp outcrops on both sides of down-ramp.

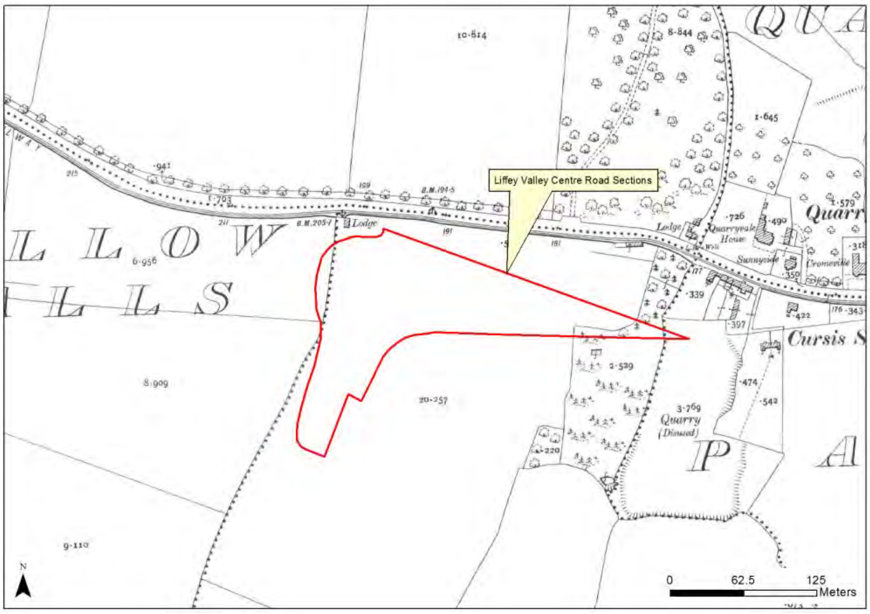
South dipping calp on west side of Fonthill Road viewed from Clarion Hotel/Liffey Valley Shopping Centre side of road.

Calp outcrop on west side of Fonthill Road R113 - looking towards N4 (bridge).

View of calp strata on east (Clarion Hotel & Liffey Valley Shopping Centre) side of Fonthill Road.


Liffey Valley Centre road section
Broomfield
Hermitage
Woodville
Quarryvale
Palmerston Lower
Knockmaroon
An Life
Palmerston
Baile Phámar
Woodfarm
Ballyowen
Ronanstown
Baile Uí Rónáin
Neillstown
Baile Néill
Clonburris Little
Ballyfermot
Baile Formaid
Cherry Orchard Hospital
Wheatfield Prison
Le Fanu Park
N4
R112
R113


Liffey Valley Centre Road Sections
N
0
62.5
125
Meters


Liffey Valley Centre Road Sections
Lodge
Quarryvale House
Sunnyside
Cromwells
Cursis
Quarry (Disused)
N
0
62.5
125
Meters

SOUTH DUBLN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**N4 Lucan cutting**
Other names used for site	
IGH THEME	**IGH8 Lower Carboniferous**
TOWNLAND(S)	**Lucan and Pettycanon, Esker South**
NEAREST TOWN/VILLAGE	**Lucan**
SIX INCH MAP NUMBER	**17**
ITM CO-ORDINATES	**703132, 734585**
1:50,000 O.S. SHEET NUMBER	**50 GSI BEDROCK 1:100,000 SHEET NO. 16**

Outline Site Description
Roadside exposure of Calp limestones beside the N4 underpass junction for Lucan.

Geological System/Age and Primary Rock Type
Bedrock consists of Lower Carboniferous (Mississippian) 'Calp' (Lucan Formation). Mainly dark grey coloured limestones interbedded with shaly limestones, and shales.

Main Geological or Geomorphological Interest
The bedrock consists of beds of dark grey-black, fine-grained limestone with interbedded calcareous shale. Calp bedrock underlies most of Dublin City. The Calp limestone is not susceptible to karstification and no major cavities occur in these rocks. The strata dip generally towards the south west and are exposed on each side of the N4 in the underpass created to keep traffic moving at a former traffic light junction. The limestone strata are typically between 10 cm and 30 cm thick, with thinner interbedded shale beds. Although there is a broad dip southwestward, there are local flexures.

Site Importance: County Geological Site
This site is of minor geological interest, but is a highly visible expression of local geology seen by thousands of people every day as they drive through the underpass. The general dip and local small scale flexures provide some interest for passengers in cars driving through the underpass.

Management/promotion issues
Owing to the high-level of traffic at this junction the opportunity for promoting geology is significant but any effort to do so must be within constraints of safety, and must not distract drivers. It is suggested here that a simple sign saying something like 'Calp Limestone – 340 million years old' might be possible, but such signage is best addressed in a strategic national approach in partnership with the NRA.

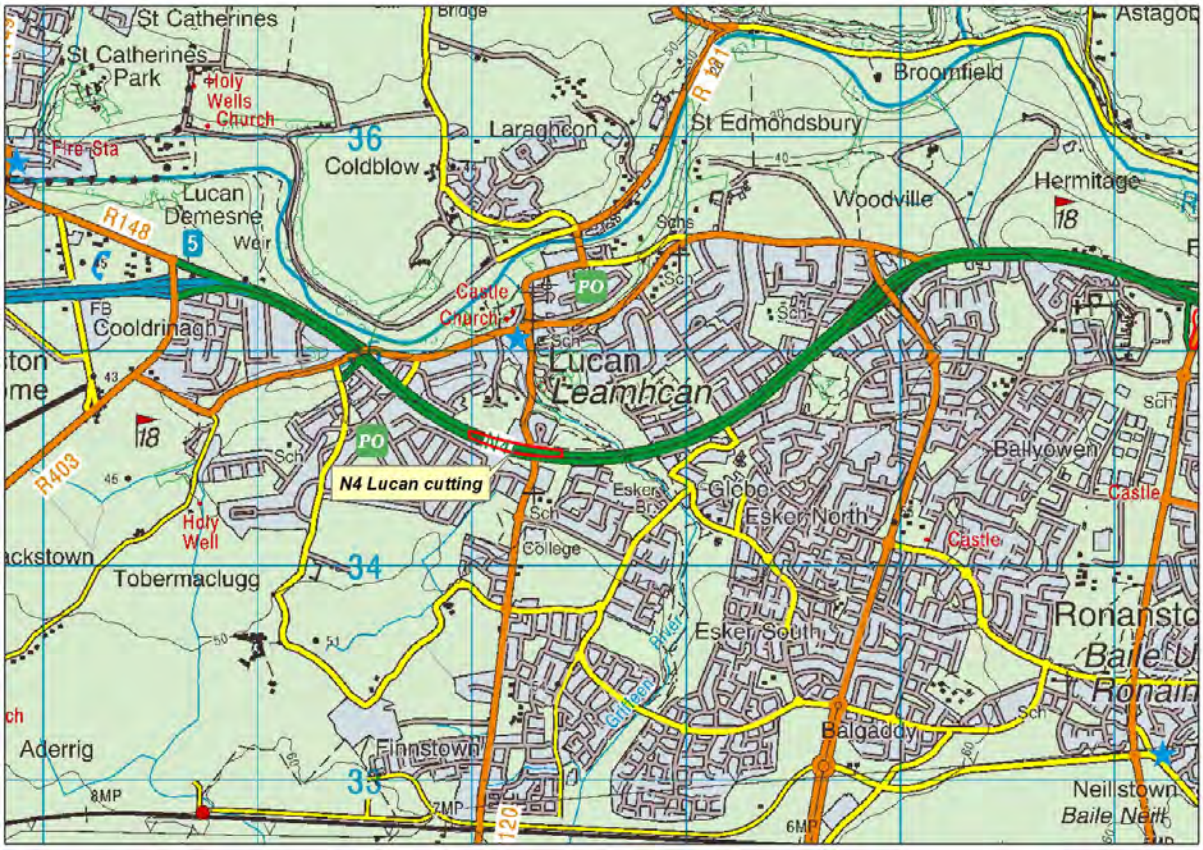
There is a problem of litter building up behind the crash barrier and over periods of tens of years, some outcrop cleaning might be advisable to remove accumulated shale debris and keep the bedded structure fresh and visible and dramatic.

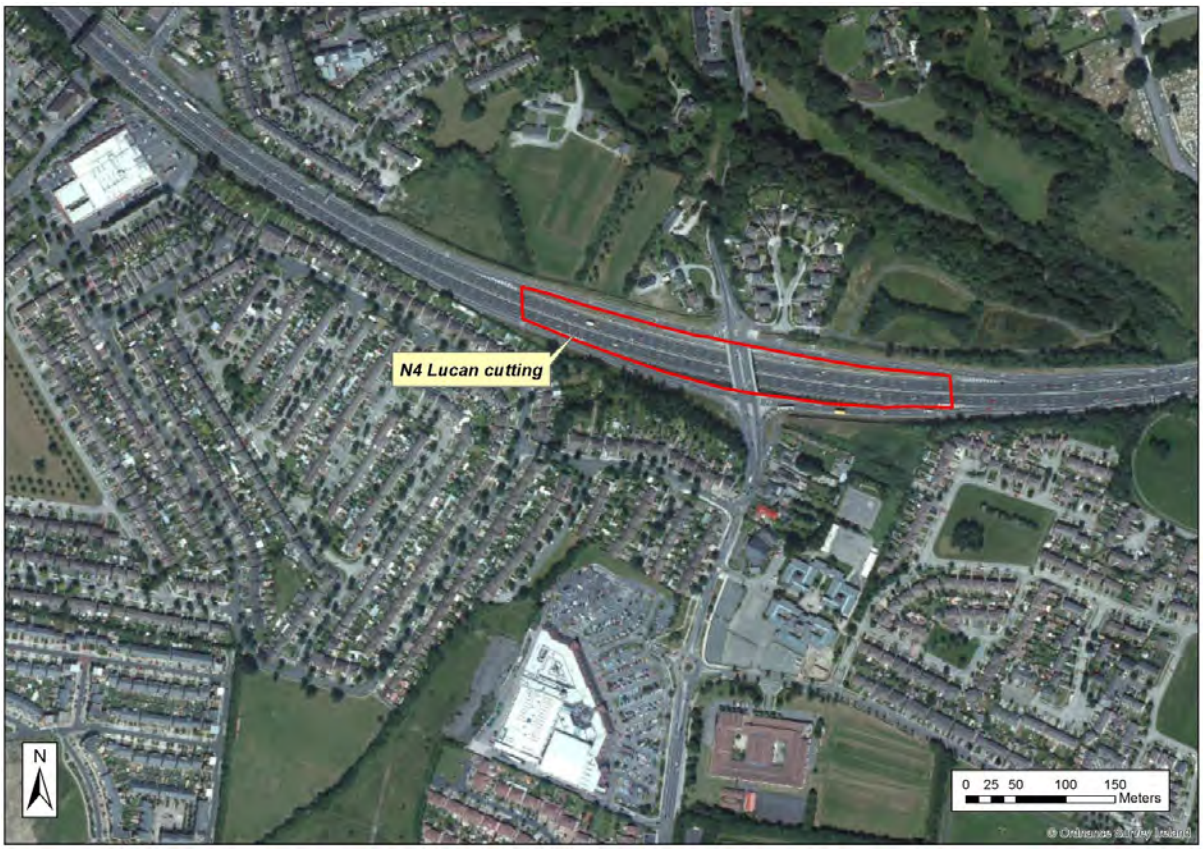
The N4 Lucan cutting viewed from the south east side.

The north west section from the bridge.

The south east section from the bridge.

The Lucan bypass improvement was opened in 2009.


St Catherines
St Catherines Park
Holy Wells Church
Fire Sta
Lucan Demesne
Weir
R148
Coldblow
Laraghcon
St Edmondsbury
Broomfield
Woodville
Hermitage
Castle Church
PO
Cooldrinagh
Lucan
Leamhcan
N4 Lucan cutting
Ballyowen
Castle
Esker North
Esker South
Holy Well
Tobermaclugg
College
Aderrig
Finnstown
Balgaddy
Neilstown
Baile Neill
R403
R120


N4 Lucan cutting
N
0 25 50 100 150
Meters

SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE	**Ballinascorney Quarry**
Other names used for site	
IGH THEME	**IGH11 Igneous Intrusions**
TOWNLAND(S)	**Ballinascorney Upper**
NEAREST TOWN/VILLAGE	**Tallaght**
SIX INCH MAP NUMBER	**24**
NATIONAL GRID REFERENCE	**707638E 722824N (centre of quarry)**
1:50,000 O.S. SHEET NUMBER	**50 GSI 1:100,000 Bedrock Sheet No. 16**

Outline Site Description
The site consists of a large abandoned quarry in the hills above Tallaght, bounded by the R114 road and a forest that covers Slievenabawnogue hill to the southeast.

Geological System/Age and Primary Rock Type
The rock is predominantly Caledonian dolerite, emplaced into Ordovician siltstones and slates of the Aghfarrell Formation. The dolerite pre-dates the Leinster Granite (405 Ma) but post-dates the main regional deformation.

Main Geological or Geomorphological Interest
Ballinascorney quarry is an excellent exposure of the Tallaght Dyke Swarm, a zone of dolerites emplaced into the Lower Palaeozoic metasediments on the western side of the Northern unit of the Leinster Granite. Individual dolerite sheets range from up to 5 m in thickness but many are multiple and have a much greater combined thickness. Such was the intensity of dolerite sheet intrusion that the host rocks are in some cases reduced to thin partitions between adjacent dolerite sheets. The dolerites are greenish-grey in colour and consist mostly of porphyritic dolerite with altered phenocrysts of plagioclase together with finer plagioclase and hornblende.

The quarry contains numerous high faces where the relationships between individual dolerite sheets and between the dolerites and their host rocks can be observed.

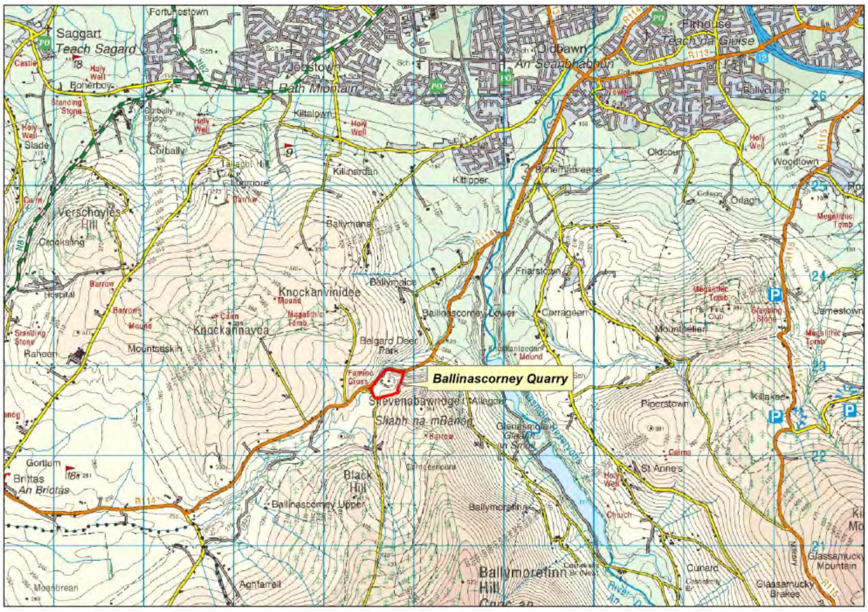
Site Importance – County Geological Site
The quarry at Ballinascorney is the best available exposure of the Tallaght Dyke Swarm. Dolerite has been intensely quarried in the hills around Ballinascorney for many years.

Management/promotion issues
A small quarry is marked on the old 19th-century 6-inch maps but most of the quarry observed today was developed between 1969 and 1979. The site is privately owned and a 2m-high chain-link fence prevents access at what was the main entrance at a sharp bend on the R114. The quarry is easily entered along an old road at the back of the quarry which can be reached via the forest road immediately to the south, but permission should always be sought from the owner. Large concrete structures, the remains of the quarry's infrastructure, remain on site. These and the high quarry faces represent a hazard and the site is not suitable for general promotion. In any case it is likely to be of most interest to geologists.

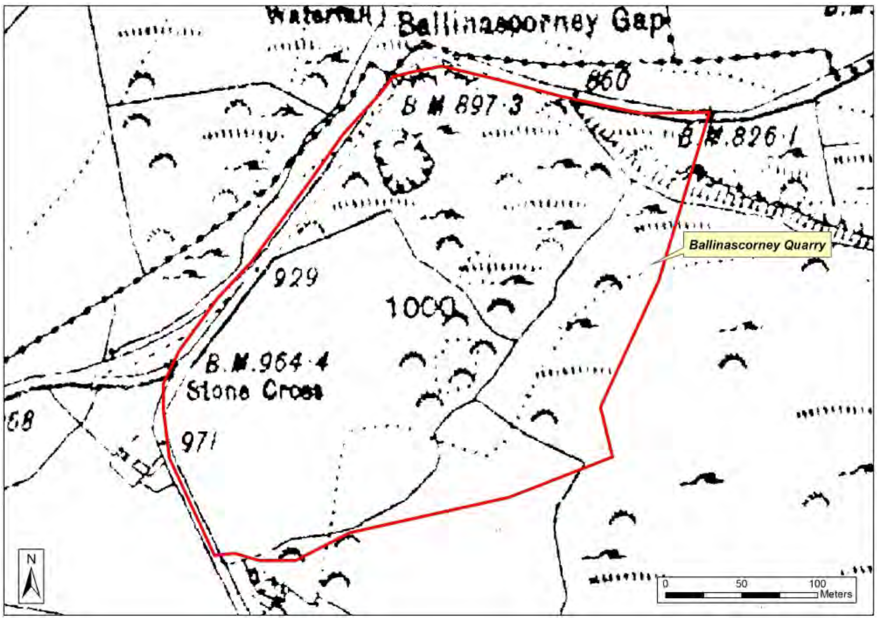
Ballinascorney Quarry entrance.

Multiple dolerite sheets, separated by very thin layers of host rock, dipping southeast (left-to-right).

Dolerite, fractured from blasting, comformable with country rock (top right).


Ballinascorney Quarry
Saggart
Teach Sagard
Fortunestown
Jobstown
Bath Mountain
Oldbawn
An Seanbhaile
Firhouse
Kiltalown
Corbally
Slade
Verschoyles Hill
Knockanvinidee
Knockannavea
Mountseskin
Rahoon
Ballymana
Ballymaice
Ballinascorney Lower
Belgard Deer Park
Slievenabawnoge / Allagour
Sliabh na mBánóg
Friarstown
Carrageen
Oldcourt
Woodtown
Pipercstown
Killakee
Jamestown
Gortlum
Brittas
An Briotás
Black Hill
Ballinascorney Upper
Ballymorefinn Hill
Aghfarrell
Glassamucky Mountain
Glassamucky Brakes
Cunard
St Anne's
Ballycullen
Oldcourt


Ballinascorney Quarry
N
0
50
100
Meters


Waterfall
Ballinascorney Gap
860
B M 897·3
B M 826·1
Ballinascorney Quarry
929
1000
B.M.964·4
Stone Cross
971
N
0
50
100
Meters

SOUTH DUBLIN - COUNTY GEOLOGICAL SITE REPORT

NAME OF SITE:	**Newcastle Buried Channel**
OTHER NAME(S):	
IGH THEME:	**IGH 12 Mesozoic and Tertiary**
TOWNLAND(S):	**Newcastle Farm, Newcastle Demesne, Glebe, Athgoe North, Newcastle South, Ballynakelly, Newcastle North, Cornerpark, Commons Little**
NEAREST TOWN/VILLAGE:	**Newcastle**
SIX INCH MAP NUMBER:	**20, 21**
ITM CO-ORDINATES:	**699440, 728477**
1:50,000 O.S. SHEET NUMBER:	**50 GSI BEDROCK 1:100,000 SHEET NO: 16**

Outline Site Description
A deep buried channel in the Carboniferous Limestone bedrock is not seen at surface and only identified and delineated by mineral exploration boreholes.

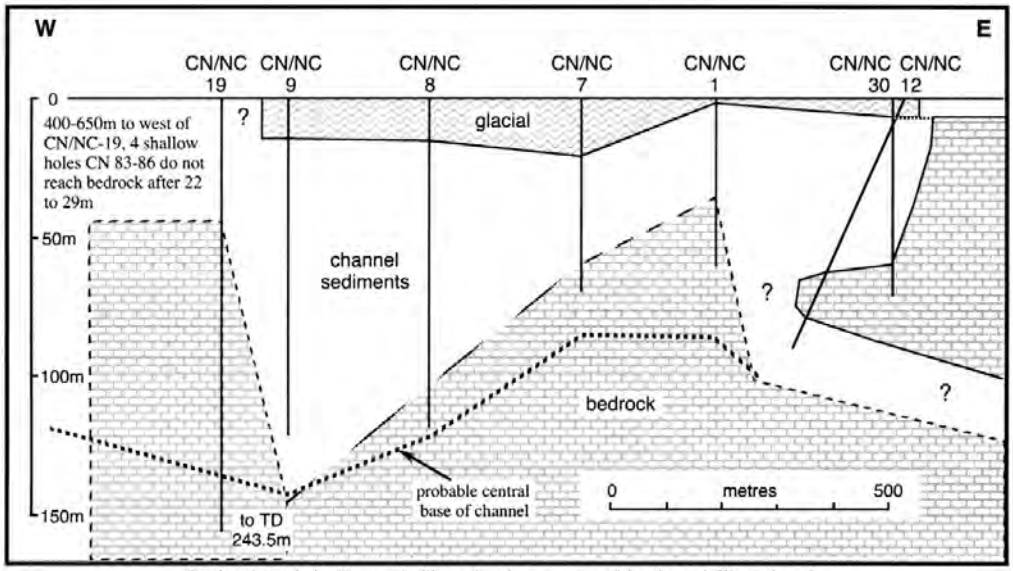
Geological System/Age and Primary Rock Type
The bedrock is Carboniferous Limestone, and the channel sediments are presumed to be Tertiary in age. Glacial till is present at surface, obscuring any outcrop of the channel or its infilling sediments.

Main Geological Interest
The buried channel was identified in 1981-1983 through mineral exploration work by Aquitaine Mining Ltd, and subsequently by Chevron Mineral Corporation. Primarily through boreholes they identified a channel approximately 100m wide, over 100m deep in places and extending for at least 2km in an east-west direction. At its eastern end, a borehole went through sedimentary fill, into bedrock and then into fill again. This feature is best interpreted as the site of a former Vauclusian Spring type cave (a large resurgence of groundwater from a cave). The sedimentary fill comprises a rich variety of coloured, sandy sediments. The mineral exploration identified high values of lead (galena), zinc and barite in the sediments but widely distributed at low percentages and therefore not an economic deposit.

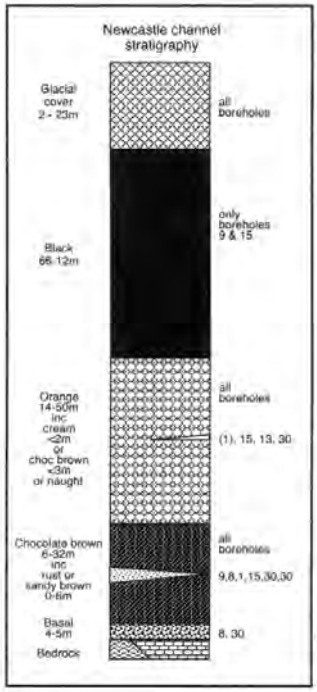
Site Importance: County Geological Site
This is an unusual site, and although not visible or expressed at surface in any way, there are sufficient boreholes and geophysical evidence to delineate the channel quite well. This report has been compiled only with the vital assistance of Gareth Ll. Jones (Conodate), based on unpublished data.

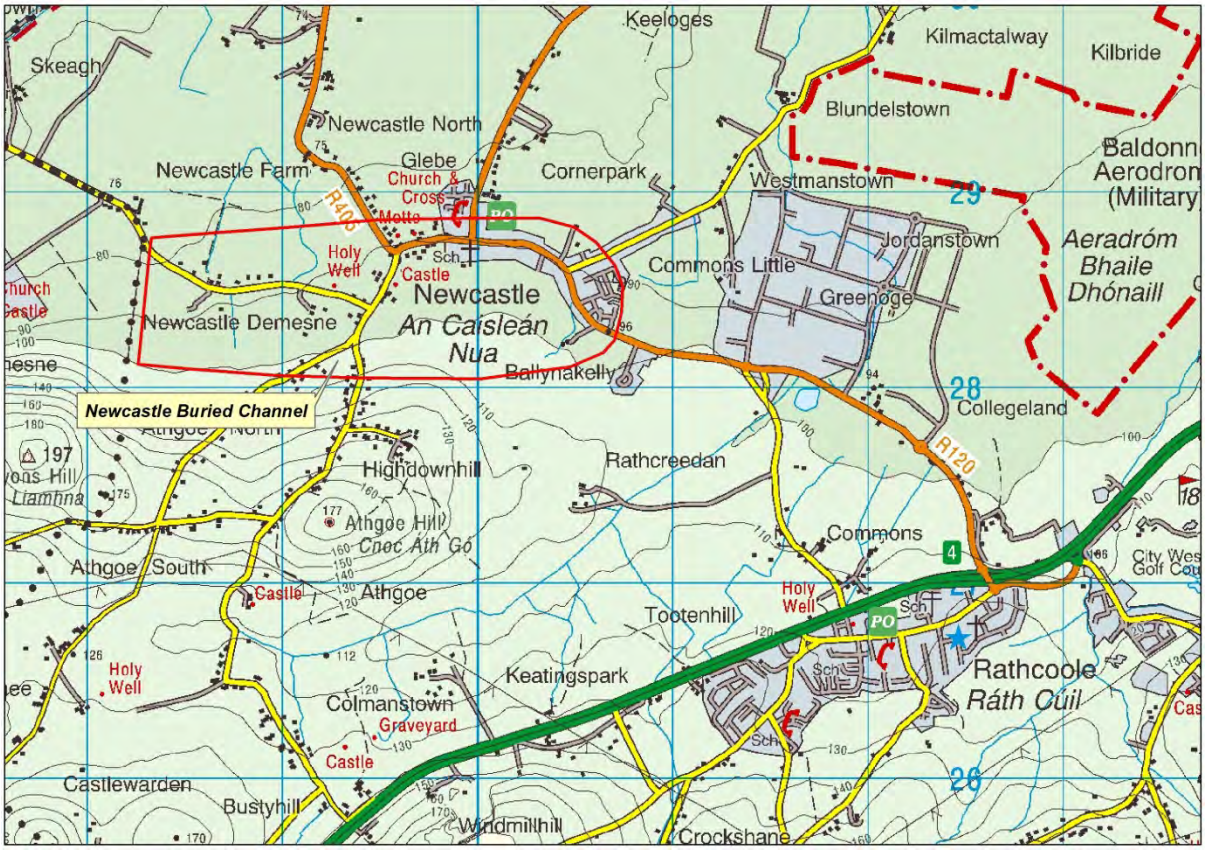
Management/promotion issues
Any development work that is within the channel area may be very interesting geologically in further characterising the feature, especially if deep excavations or boreholes are part of the proposed work.

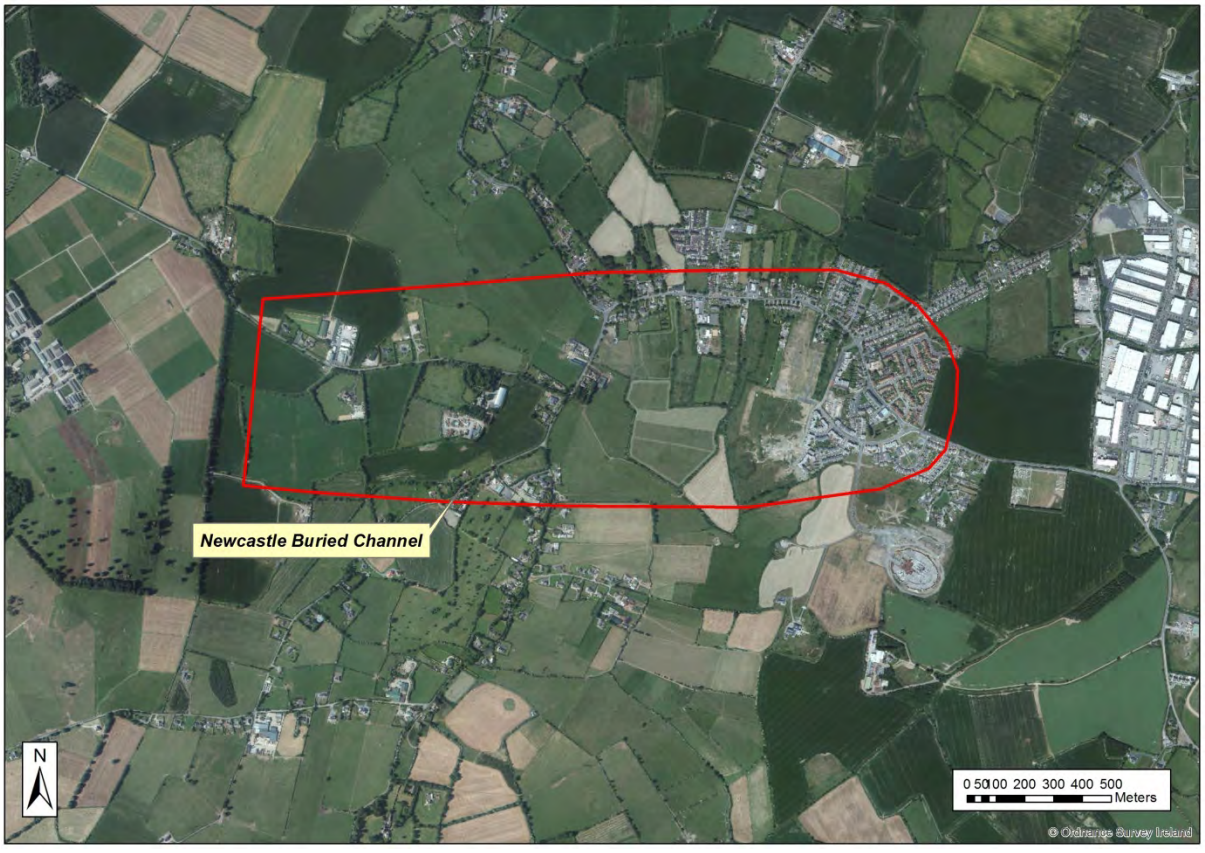
The Newcastle area of the buried channel, viewed from Crockaunadreenagh to the southeast, showing the flat terrain.



Section through the Newcastle Channel and a summary of the channel fill stratigraphy




Newcastle Buried Channel
Keeloges
Kilmactalway
Kilbride
Skeagh
Blundelstown
Newcastle North
Newcastle Farm
Glebe
Church &
Cross
Motte
Cornerpark
Westmanstown
Baldonn
Aerodron
(Military
Jordanstown
Aeradróm
Bhaile
Dhónaill
Commons Little
Greenogue
Holy
Well
Castle
Newcastle
An Caisleán
Nua
Newcastle Demesne
Ballynakelly
Collegeland
Rathcreedan
Highdownhill
Athgoe Hill
Cnoc Áth Gó
Commons
Athgoe South
Athgoe
Tootenhill
Rathcoole
Ráth Cúil
Keatingspark
Colmanstown
Graveyard
Castlewarden
Bustyhill
Windmillhill
Crockshane


Newcastle Buried Channel
N
0 50 100 200 300 400 500
Meters
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