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Sub-Urban

TU1206-WG1-004

Dublin

TU1206 COST Sub-Urban WG1 Report

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COST TU1206 Sub-Urban Report
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Subsurface and urban planning in the City of Dublin

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Cover image: aerial photo of Dublin City (Photo taken by NGU staff for the SURGE project)

Acknowledgements

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Contents

1 Introduction

Overview

Dublin is Ireland's capital and largest city with a population of 527,612 (2011) and it lies on the East coast of the Ireland (Fig1). The Dublin metropolitan area is Ireland's financial and administrative centre. Dublin is the hub of Ireland's transportation networks and a key gateway for international trade via air and sea. The Republic of Ireland has a total population of c. 4,588,000 and of that population c. 1,273,000 live in Co. Dublin making it the most densely populated part of the country.

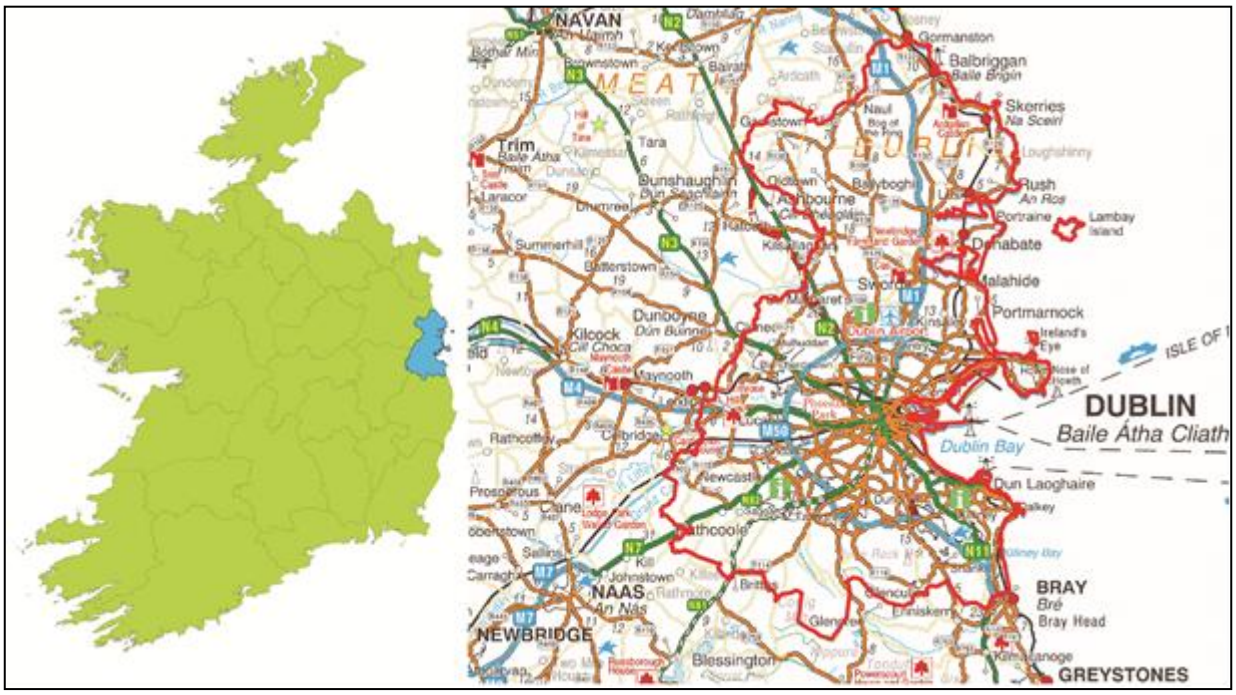

Fig1 Location of County Dublin (red outline) relative to the Republic of Ireland (Licence No. EN 0047212)

The Dublin Region comprises the administrative areas of Dublin City Council (pop. 528,000), Fingal County Council (pop. 274,000) South Dublin County Council (pop. 265,000), and Dun Laoghaire-Rathdown County Council (pop. 206,000) (Fig2). With the exception of Dublin City, each of the county administrative areas has a mix of rural and urban zones.

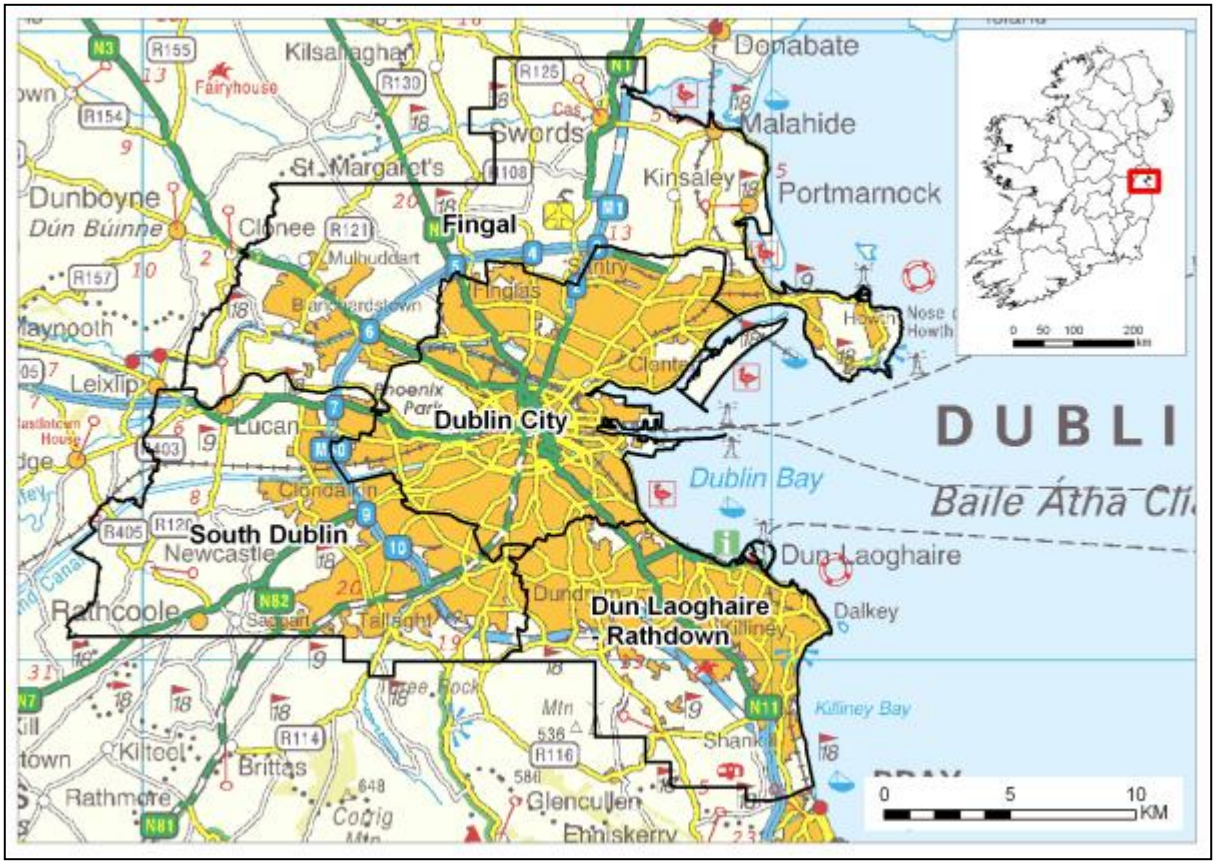

Fig2. Study area showing local authority administrative areas

The most urbanised and densely populated part of the City is administered by Dublin City Council. This central part of the city also reflects port and industrial land-use, brownfield regeneration and major infrastructure hubs and networks. The councils remit includes environment, recreation and sport, strategic planning and economic development, roads and transportation, housing and community, planning and development and culture and amenity. The administrative boundary in Fig3 corresponds to the Dublin City Council boundary and the area under consideration in this report.

Since the 90s, the landscape of Dublin has change dramatically due to the rapid economic expansion during the Celtic Tiger period.

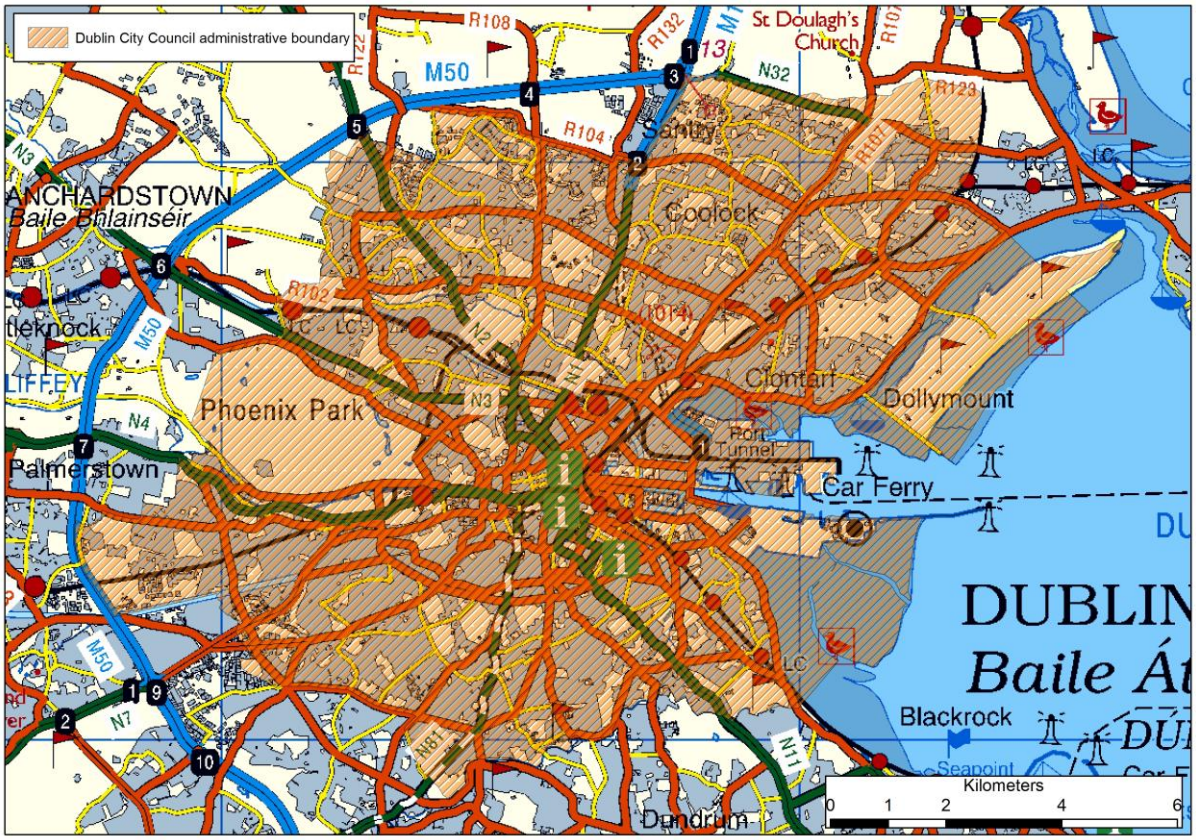

Fig3. Dublin City Council administrative boundary (Licence No: EN 0047212)

City description

County Dublin (Fig1) is located on Ireland's eastern coastal margin and occupies an area of 920 km² (c. 1.3% of the total area of the Republic of Ireland). Dublin is situated at the mouth of the River Liffey. It is bordered by a low mountain range to the south and surrounded by flat farmland to the north and west. The Liffey divides the city in two between the Northside and the Southside (Fig3).

Social

- Dublin is the biggest city in Ireland with a population of 527,612 (CSO, 2011). 1,273,000 live in Co. Dublin making it the most densely populated part of the country.
- The number of households in Dublin City has decrease dramatically due to the recession. Demographic change implies that between 2011 and 2021, 180,000 additional housing units would be required for Ireland. From those, over 60% of these are required in Dublin.
- 2011 Census shows a decline in general health with age. People who live in the suburbs have better overall health compared with the people who live in the City Centre.
- Dublin City Centre has population age average of 36.6-37.3 making it slighter older than the surrounding counties, but slightly younger that the west of the country.

Environment, land use and infrastructure

- The total number of dwellings in the City of Dublin is 207847 (CSO, 2011) from those:

  - 10837 are detached houses
  - 47998 are semidetached houses
  - 74179 are terraced houses
  - 54639 are flats or apartments in a purpose built block
  - 10858 are flats or apartments in a converted house or commercial building
  - 3697 are bedsits
  - 5639 are not stated

- According to the 2011 Census, 55% of commuters living in Dublin City and suburbs drove to work. 62693 people walk to work. 21% used the public transport to work and 5.9% cycled to work.
- Dublin City Council is responsible for approximately 1400 hectares of public open space dispersed throughout the city in the form of public parks and other spaces associated mainly with residential developments.
- Climate change predictions in Dublin City indicate and increase in the risk of flooding. This suggests that coastal defence systems may have to be implemented.

Economy

- Economic activity in the Dublin region accounts for 47 %of national GDP.
- 34% of the State's workforce lived in the Greater Dublin area in 2011.
- Some 84,000 people were employed in the Dublin Region in 2013, representing over 40% of the total number of people employed in the State.
- In Dublin City, the proportion of persons over 15 with a higher level of education is 35%.

Geological Setting of Dublin

The bedrock geology of Co. Dublin (Fig4) represents a long and somewhat fragmented record of palaeoenvironmental conditions and processes and a variety of tectonic settings that contributed to the current distribution and characteristics of rocks. Lower Palaeozoic (540 - 415 million years ago) metasedimentary and volcanic rocks are mainly found in the north and south of Co. Dublin while the central zone is underlain by Upper Palaeozoic (415 - 250 million years ago) rocks of Carboniferous age (360 - 300 million years ago). Emplacement of granite into the southern Lower Palaeozoic rocks occurred at around 400 million years ago (Devonian).

The oldest rocks in County Dublin are the Cambrian (540 - 490 million years ago) greywackes, slates and quartzites of Howth Head.

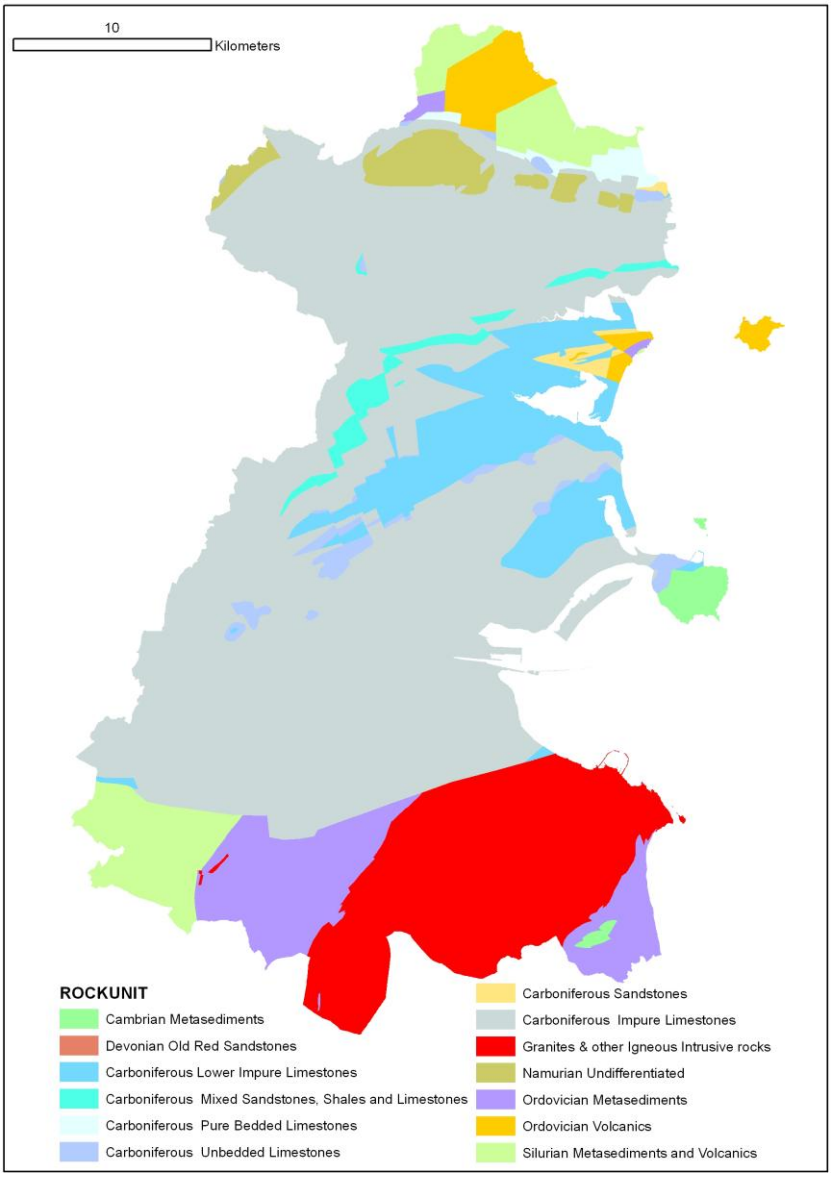

Fig4 Simplified bedrock geology of Co. Dublin

Rocks of Ordovician age (490 - 445 million years ago) are found in two locations in Co. Dublin: schists and other metasedimentary rocks around the eastern and western flanks of the Leinster batholith in the south Dublin Mountains and a series of metamorphosed volcanic rocks and mudstones around Ballbriggan in north Co. Dublin.

Silurian (445 - 415 million years ago) metasedimentary and volcanic rocks occur within the south Dublin Mountains adjacent and to the west of the Ordovician rocks and also in the north of the county. At this time, Iapetus Ocean closure was in its final stages and continental collision and mountain building of the Caledonian Orogeny began.

In Devonian times (415 - 360 million years ago) granite was intruded in a shear zone along the north-east trending foliation of the Lower Palaeozoic host rocks. This intrusion during the Caledonian Orogeny was precipitated by the deformation of the continental masses as they collided.

Carboniferous rocks are the most common rock types in Co. Dublin. They are delimited to the south by a faulted contact with the Lower Palaeozoic rocks and the Leinster batholith and by Lower Palaeozoic Rocks to the north. The oldest Carboniferous rocks in Co. Dublin are argillaceous bioclastic limestones and shales. Younger Carboniferous rocks overlying these include pure poorly bedded limestone. In the north and central zones, dark calcareous mudstones which occasionally contain framboidal pyrite (potentially making these rocks unsuitable for use as construction materials) overly the pure poorly bedded limestones. The most extensive Carboniferous bedrock rock type, colloquially known as the Calp, covers most of the central zone and some of the northern parts. It consists of laminated argillaceous calcisiltites, calcareous shale and thinly bedded locally cherty limestone interbedded with black shale. These rocks were mainly deposited in warm shallow marine environments.

The youngest Carboniferous rocks were originally deltaic sands and muds often deposited in swampy conditions during the Namurian Stage (326 – 313 million years ago) of the Carboniferous. These are to be found in north Dublin forming the higher ground in that region. They consist of mudstones, shale, siltstones and sandstones, with occasional thin coal seams.

The effects of Quaternary age (2.6 million years ago until the present day) glaciations on the landscape stem from ice flowing and retreating over the area from different ice-bodies that extended from a number of well-defined centres, each deflecting the flow pattern of the other where they met and coalesced. It is thought that a local ice centre in the Dublin and Wicklow Mountains advanced over the area followed by several advance, retreat and readvances of the Irish Sea Ice Sheet (ISIS).

Subsequently the Northern Dome Ice Sheet advanced on a south-eastwards direction overriding most of the sediments deposited by the ISIS, this ice sheet extended offshore to the east and is delimited to the south by discontinuous mounds of sand and gravel occurring along the north margin of Dublin Mountains. Finally, a small readvance of the Wicklow ice dome is recognised from glaciofluvial material. The dynamic nature of the environment resulted in the deposition of a range of sediments types over the area, each with different and often internally variable characteristics. For example, Interbedded sand and gravel layers in glacial tills as seen in Fig5 can have important implications for certain types of infrastructural development.

At the end of the glacial period, sea level was far lower than current levels and glaciofluvial rivers incised deep channels through the material left behind by the direct action of ice (tills) and cut into the bedrock in some areas. These channels were in turn infilled with glaciofluvial deposits. The modern river systems of Co. Dublin still follow some of these ancient channels but others are abandoned with important implications for certain types of infrastructural development.

Following the deglaciation of the area, compressible Holocence Epoch (10,000 years ago until the present day) sediments were naturally deposited by rivers and in lakes and also created with human intervention. These sediments include alluvial deposits in the river channels, estuarine silts and clays and reclaimed land. Man-made deposits, known as fill cover much of the City centre: these deposits vary widely in composition and thickness throughout the area. A map showing the distribution of the Quaternary sediment cover is shown in Fig6.

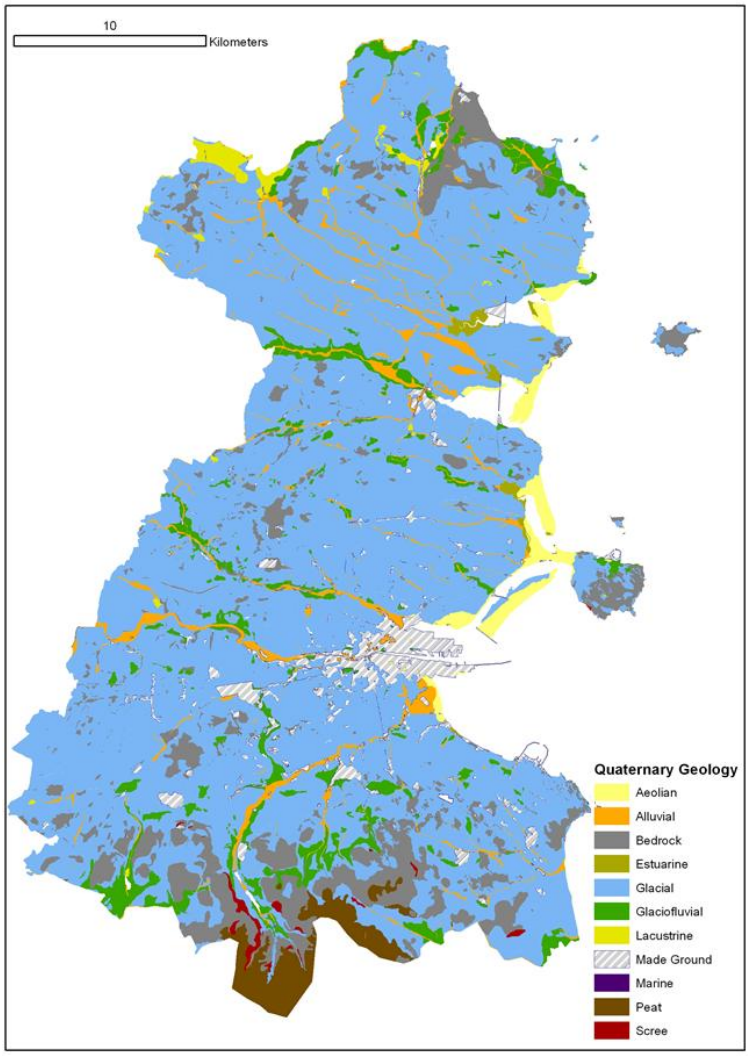

Fig5 Simplified representation of the Quaternary geology of Co. Dublin

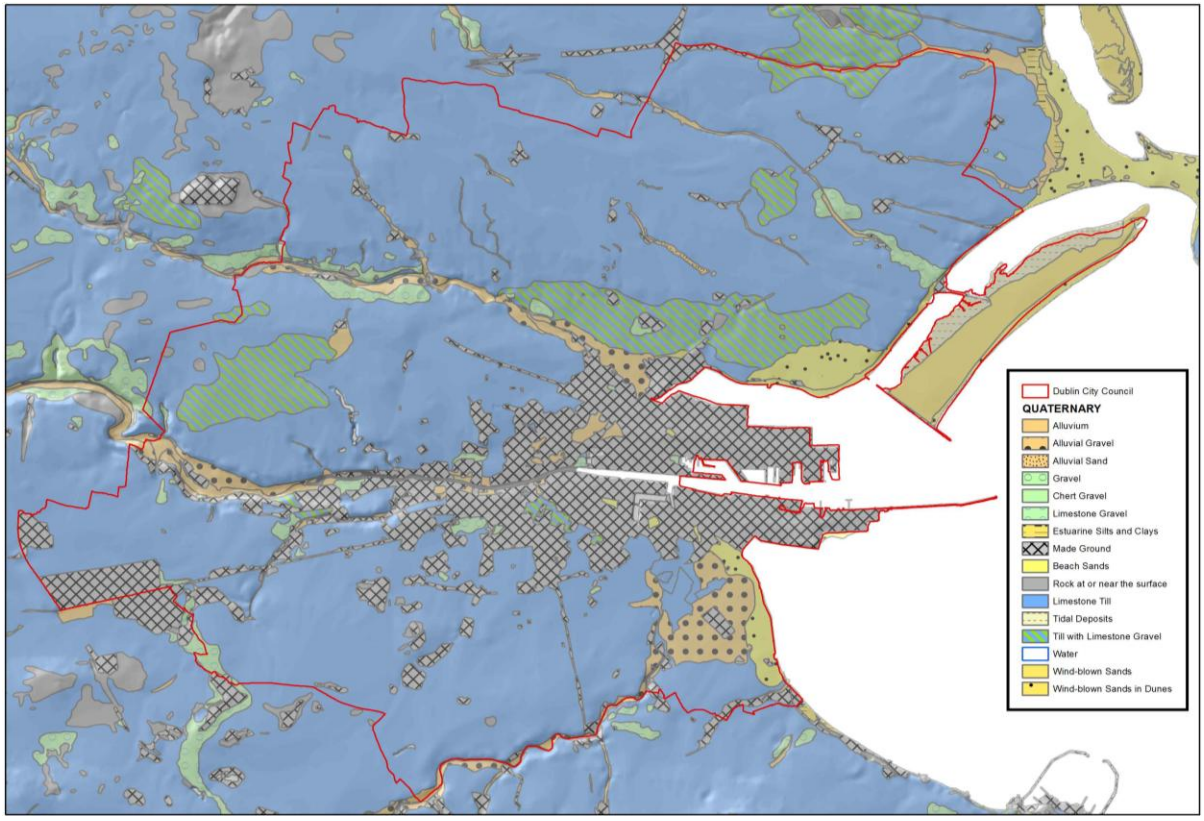

Fig6 Quaternary Geology of Central Dublin

2 The urban subsurface environment

Soils, artificial ground and superficial deposits

In the Dublin City Centre, the bedrock is totally obscured by the overlying glacial and postglacial deposits. (Fig6).
Glacial Till (Boulder Clay) has a widespread distribution across central Dublin. It has traditionally been divided into two strata, an upper brown Boulder Clay and a lower black Boulder Clay for engineering purposes, the upper unit being a weathered facies of the lower. These sediments can vary greatly in thickness from a few metres to upwards of 20m.
The till contains water-bearing lenses of sand and water. Glacial and postglacial terrace gravels are found along the river Liffey overlying by recent alluvium deposits.
There is a considerable area of intake from the sea in the east of the city where sediments intrudes into the glacial materials.
The bedrock topography is dominated by a major buried channel. Away from this channel the bedrock lies at shallow depths of 5 to 10m below ground level (BGL) on average across the central city. The channel runs into Dublin Bay where it reaches a depth of -40 m BGL and it is 2.5kms wide.
The channel is filled with postglacial intertidal and estuarine deposits overlying a basal glacial till.
Made ground around the Dublin city area comprises filled used for the reclamation of the tidal land and the port area, made ground of archaeological interest and old quarries of the city.

This summary of the subsurface geology of the Central Dublin illustrates the complexity of the superficial deposits in terms of both their type and thickness and the variable depth to the bedrock found across the city. The delineation of the buried channel including its depth, width and sediment fill is crucial in the context of underground infrastructure and planning.

Groundwater

The bedrock of the Dublin urban region is mainly composed of bedded dark limestones and shales known as 'Calp'. Groundwater flows through fissures within the bedrock. Fissuring is most prevalent in the top 10-20 metres of the bedrock, with isolated deeper fractures occurring less frequently. In general, the permeability of these rocks is relatively low, heterogeneous, and decreases with depth. However, higher yielding zones are encountered when fault zones are intersected. Well yields are typically in the range 50-200 m3/d, although failed wells and greater yields can be achieved. Aquifer units are classified as Ll: Locally important aquifers that are moderately productive only in local zones. Glacio-fluvial sand and gravel deposits are known along the River Liffey. Where saturated, these deposits provide both a groundwater pathway and additional storage.

Groundwater recharge via infiltrating rainwater is restricted by made ground, and also by the low permeability limestone tills which cover the bedrock. Recharge can occur, however, and will particularly do so in areas of parkland, or suburban garden areas. Groundwater is also recharged by leaking water distribution mains and in areas with older sewerage networks.

Overall, groundwater resources in Dublin are limited by both naturally modest aquifer potential, and from anthropogenic impacts on water quantity and quality, although small industrial, municipal and private abstractions within the city centre and suburbs are known. The existing public drinking water supplies for the Dublin region are derived predominantly from surface water, with the majority of

water coming from the Vartry, Dodder and Liffey River catchments. North county Dublin's water supply is augmented by groundwater abstracted from a productive fissured aquifer at the Bog of the Ring in Fingal.

Geochemistry of Dublin

The Geological Surveys of Europe (EuroGeoSurveys) have initiated an urban soils project in order to highlight the importance of the assessment of urban soils in European cities. Under this initiative, the GSI, in partnership with the Geological Survey of Norway, undertook systematic geochemical mapping of soils in the greater Dublin urban area.

GSI carried out in 2009 a chemical survey of the topsoil around Dublin city and county. It involved taking and analysing samples of soil from areas that are publicly accessible (e.g. public parks and school grounds).

A total of 1058 samples were taken in topsoil (0-10cm depth) in the greater Dublin area in October and November 2009. Sample locations were chosen randomly to give an overview of baseline conditions in the city. All samples were analysed for 31 inorganic elements including heavy metals and 194 were also analysed for Polycyclic aromatic hydrocarbons (PAHs) and Polychlorinated bipheyls (PCBs).

Results for heavy metals indicate that the concentrations of lead, copper, zinc and mercury are strongly influenced by human activities. The concentrations of these metals are elevated in the docklands, inner city and heavy industry areas. Sources of heavy metals in these areas include historic industry such as metal and chemical works, coal burning in homes and industry, reuse of contaminated soil and modern traffic. Lead concentrations are considered high in inner city locations, a trend which can be attributed to the historic use of leaded paint and petrol in addition to the sources described above.

PAHs were detected across the city, with maximum concentrations occurring in the city centre. Concentrations decline towards the outer suburbs. This trend reflects historical sources of domestic coal burning, industrial emissions and modern traffic which are associated with city centre locations.

Results for PCBs in soil indicate isolated, low level detections of PCBs in Dublin, mainly in the city centre. The PCB compositions in soils indicate that contamination is probably associated with historical industrial sources and old paint rather than modern, active sources.

It is recommended that a contaminated land guidance and regulatory regime is put in place for Ireland, in order to prevent deterioration of Ireland's soil resource, especially in urban areas. Experience from the UK, the Netherlands and Norway shows that establishment of authoritative contaminated land guidance relies on the close cooperation of health authorities, regulators and environmental experts and it is recommended that an inter-agency group of such experts be established in Ireland.

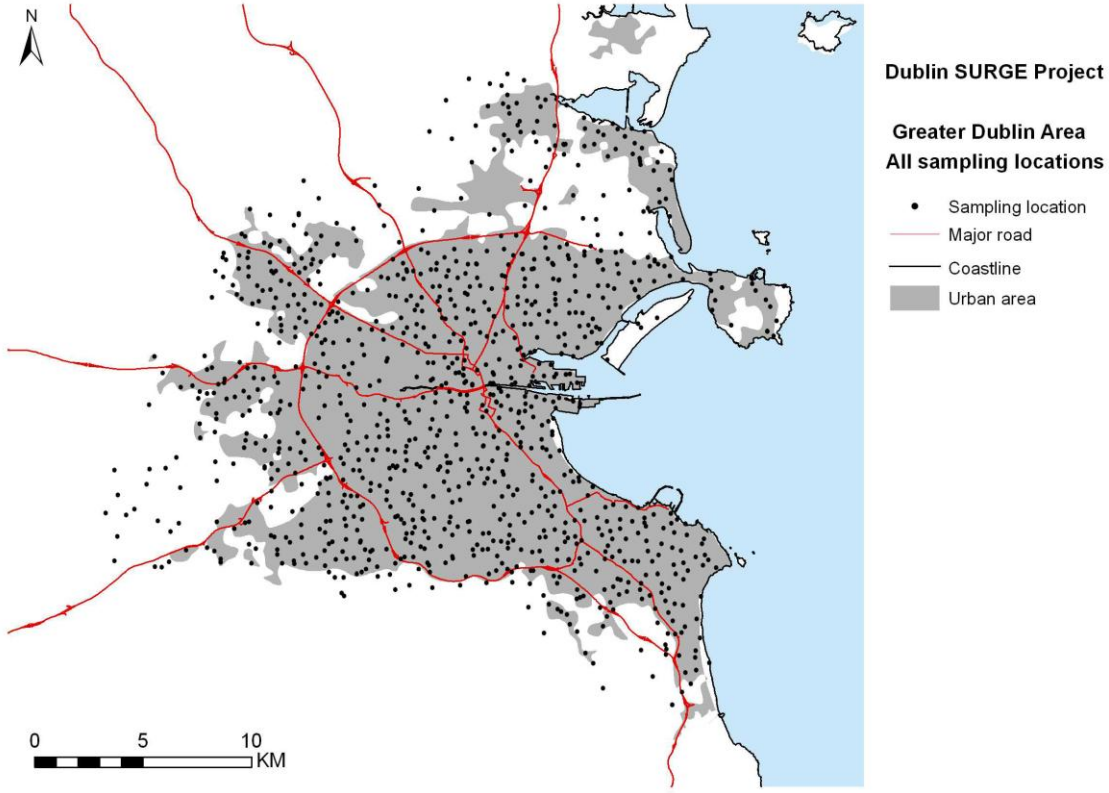

Fig7 All sampling locations map (n=1058)

A detailed report was generated as part of this project and can be accessed at: http://www.gsi.ie/NR/rdonlyres/1F23753A-D662-44D3-AE78-5029700472AE/41993/DublinSoilUrbanGeochemistry.pdf

Geological Hazards & Instabilities in Dublin

Mapping and understanding the nature of geohazards (geological hazards) such as ground subsidence and ground heave, earthquakes, tsunami, volcanic eruption, landslides, Radon gas emission, solution of bedrock, liquefaction etc, lies at the start of a continuum of analysis that lead to accurate risk analysis. Understanding these geohazard phenomena enables society to adopt appropriate mitigation measures to reduce exposure and increase resillience. In a world-wide context Dublin is considered to be a geological stable city as it does not suffer from near field (close-by) effects of major geohazards. Nevertheless Dublin's spatial position at the interface of land sea and river environments presents a set of geological challenges to engineering that can manifest as geological hazards. Ground instability, coastal inundation and volcanic erruption are the main geohazards that have potential to impact on Dublin City.

Ground Instability

GSI participated in the FP7 funded PanGeo project which has developed ground instability maps and reports for 52 large centres of population in the EU (~13% of the EU population). The project's main objective is to enable free and open access data and geohazard information using Persistent

Scatterer Interferometry (PSI) observations (a technique that uses satellite radar data). To achieve this end GSI developed a 'ground stability layer' which describes the spatial location and extent of geohazards for Cork and Dublin including 'ground stability reports' that describe the evidence for and the nature of the geohazards. This free online geohazard information service is delivered through the PanGeo portal: http://www.pangeoproject.eu.

Geohazards in Dublin city have been mapped by the GSI and the detailed local knowledge of geohazards has been combined with PSI observations of ground movement to create a comprehensive map of geohazards present in Dublin. GSI has developed 'ground stability layer' maps and interpretive reports for Co. Dublin and Cork City. From an exposure perspective these two areas combined cover over 30% of the Irish population in an area encompassing less than 1.3% of the Republic of Ireland's land area. This Irish work builds, in part, on data from the Terafirma project and the Urban Atlas (both ESA GMES funded projects) with new ERS and Envisat PSI datasets for Dublin developed in the course of the project.

This work has led to the delineation of 9 polygons (areas) within which potential or observed ground instabilities are identified. These polygons cover an area of c. 33.5 km² which is less than 4% of the entire Dublin interpretation area (920km²). The main observed instabilities (by area) are associated with compressible ground (Sheehy & Verbruggen, 2013).

Coastal Inundation

GSI is conducting research focused on vulnerability to coastal inundation along the coast of Dublin Bay. This research includes the impact of anticipated future climate change in the scenarios it presents.

GSI plays a role in Ireland's emergency management during volcanic eruptions and tsunamis. In terms of National Emergency Management DCENR (parent department of GSI) is the Lead Government Department (LGD) for the issues of tsunami and earthquake.

GSI represents Ireland on the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System for the North-eastern Atlantic, Mediterranean and Connected Seas. As part of this, GSI participates in tsunami simulation exercises based on earthquake-driven scenarios. These simulation exercises include Dublin Port as a forecast point for estimated initial tsunami arrival times and indicated tsunami wave heights.

3 Subsurface information for Dublin

The GSI has collected data in Dublin City Centre for many years.

Quaternary maps have been compiled and updated (Robbie Meehan 2013) across the County.
Bedrock maps have also been updated, by merging the updated 50K map of Co. Dublin into the 100K bedrock map, registered to the new coastline from the Ordnance Survey of Ireland (OSI 2013).
The GSI also holds the National Geotechnical Borehole Database. The database has been assembled over several decades and has expanded rapidly in recent years with the quick expansion of the Irish economy.
The GeoUrban project was a Geological Survey of Ireland initiative funded through the NDP (National Development Plan) 2007 - 2013. The aim of the project was to create a web enabled, free access, 2D/3D/4D geo-environmental GIS for Ireland's largest urban zone. The project outputs provide a geological framework that facilitate informed planning and infrastructural decision making in the Greater Dublin region, including forward looking scenarios.

Geotechnical Database

GIS holds the National Geotechnical Borehole Database (NGBD). It contains over 7500 ground investigation reports with data on more than 92,000 boreholes and trial pits

It contains the reports of site investigation work undertaken to determine the ground conditions at the location of proposed development projects. The reports typically contain a text report and borehole, trial pit and probe logs, as well as field tests and laboratory sample analyses and a site map.

The reports come from:

- Public sector like road, rail, water, sewerage and gas pipeline infrastructure.
- Private sector like residential, commercial or industrial developments.

The Database is a particularly important national asset with regard to infrastructure development and especially initiatives such as Transport 21.
As part of the development of the NGBD a dedicated web viewer was deployed to allow free and open access to all the NGBD data.
The viewer has a high degree of functionality allowing: search, display, select, download, extract data, print etc… http://www.gsi.ie/Mapping.htm

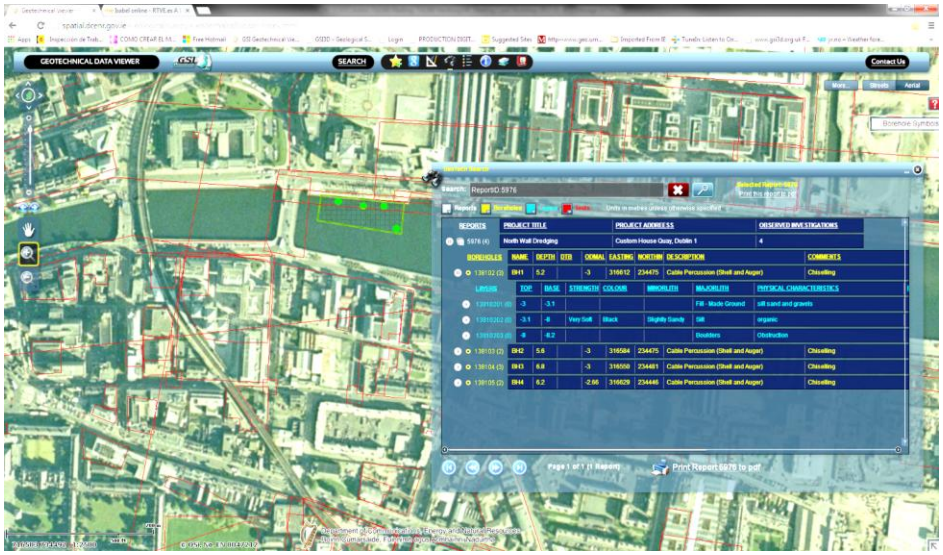

Fig8 geotechnical viewer

Geological Models — History and state of the art

Sustained gathering and entry of Site Investigation (SI) data into the National Geotechnical Borehole Database (NGBD), over the past decades, has provided the requisite density and redundancy of data to enable 2D & 3D modelling of the subsurface in the urban centres of Dublin.

These models allow new insights into the nature and distribution of the geological units that underpin some of Ireland's most important infrastructure.

2D Modelling

As the amount of site investigations digitised increases ever year, Depth to bedrock contour maps, Rockhead OD maps, and 3-D models of the bedrock topography have been generated for Dublin.

These maps are periodically upgraded as new data is added to the database. The newest version is from July 2013.

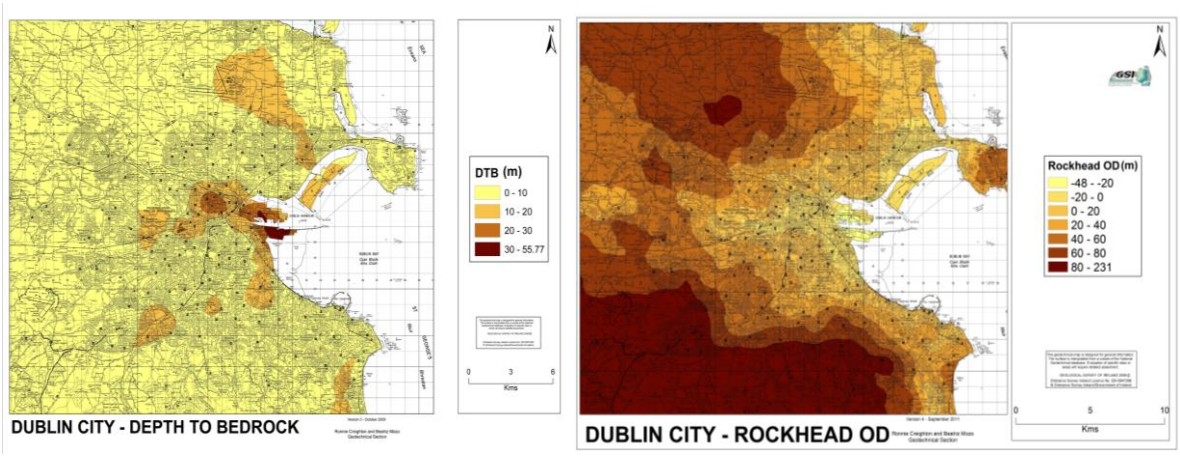

Fig9 Depth to Bedrock and Rockhead OD products

The rockhead 2D surface was clipped to the DTM of to give the 3D component.

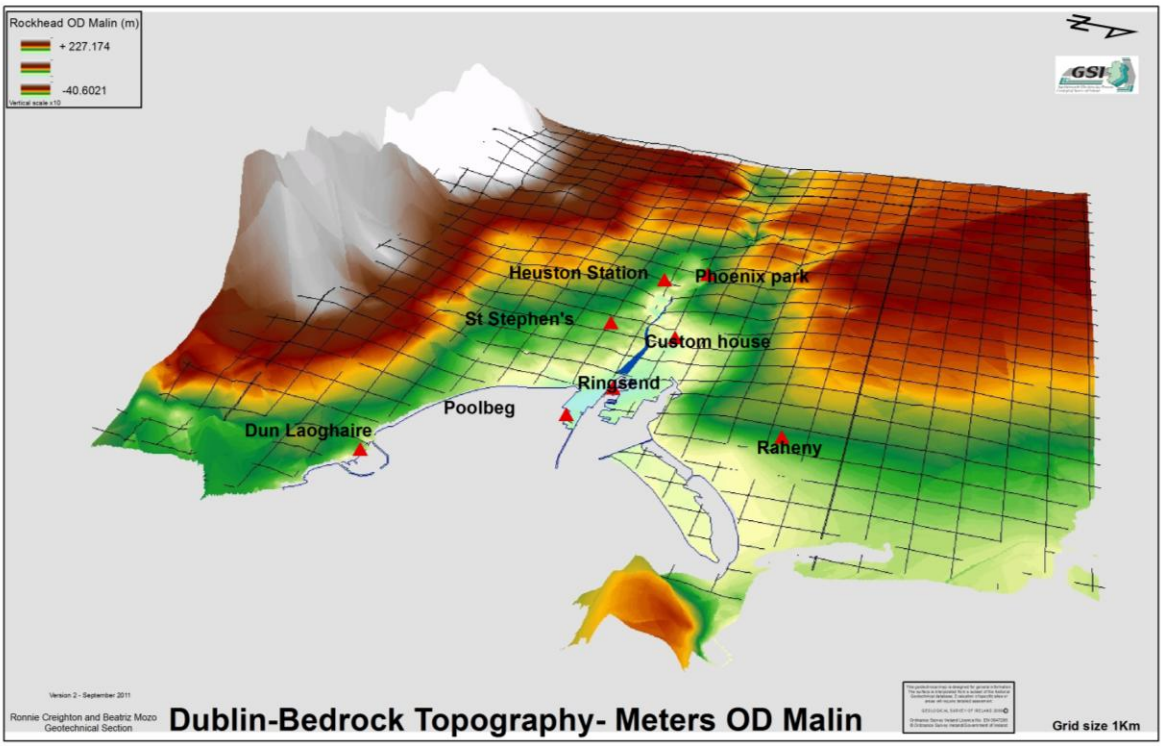

Fig10 Visualisation of Bedrock Topography (with vertical exaggeration)

3D Modelling

The 3D modelling of the Quaternary sediments was done using GSI3D which is a methodology and associated software tool for 3D geological modelling. The software is being developed by the British Geological Survey.

The success of the GSI3D software is based on the fact that it utilizes exactly the same data and methods that geologists have been using. It allows adding new data all the time so the model can be updated.

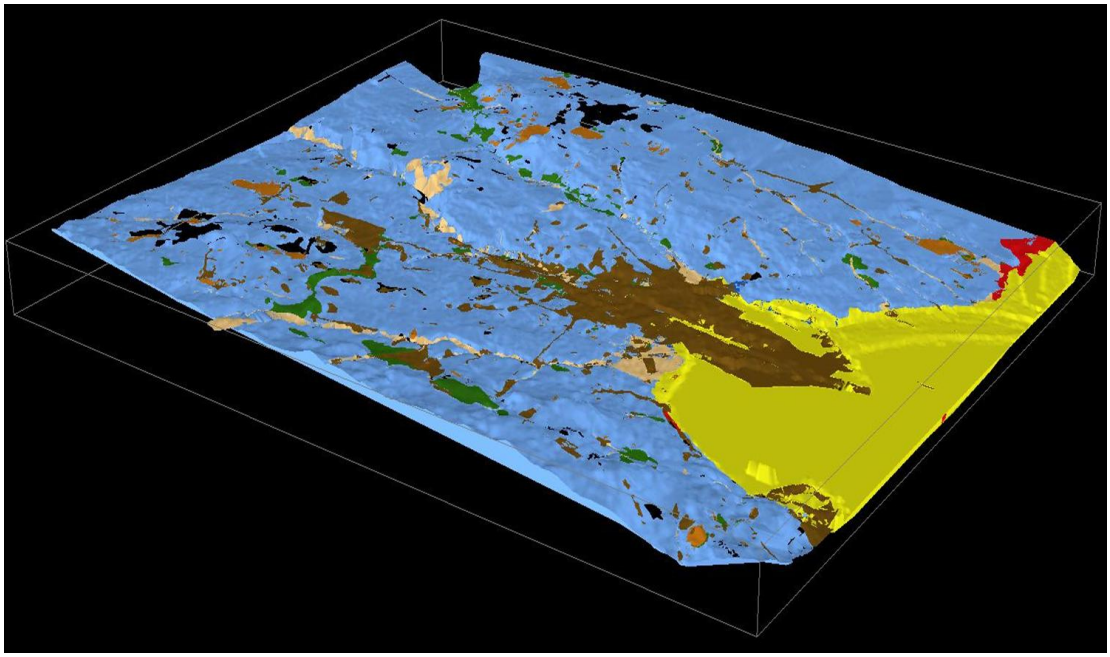

Fig11 Quaternary Model of Dublin City Centre

4 Urban planning and Management

Dublin's city development plans are agreed visions for the future of Ireland's economic and infrastructural centre. The development plans run over a period of years and consider the needs of the city and reflect national objectives and plans. The day to day granting of planning and development licences is governed by these frameworks and Irish planning legislation.

The Irish Planning Process

In Ireland, for most of the developments, applications for planning permission are made to the planning authority for the area in which the development will be sited i.e. local County Council, Borough Council, City Council or Town Council.

Those developments exempted from this are set out in a planning law (Schedule 2 of the Planning and Development Regulations 2001) http://www.irishstatutebook.ie/2001/en/si/0600.html#sched2

In the planning application the developers have to complete a checklist in conjunction with the planning application form. (http://www.dublincity.ie/sites/default/files/content//Documents/Application_Forms/Planning/CombinedinfochecklistexternalApril2014.pdf)

City Development Plan 2011-2017

The Dublin City Development Plan sets out policies and objectives to create a sustainable and vibrant city at the heart of the Greater Dublin Region. This plan guides how and where development will take place in the city over the next 6 years. [www.dublincitydevelopmentplan.ie]

It includes several priorities, each one with specific policies and objectives. Four of the priorities relate to making Dublin compact, connected, clean and green, three relate to the innovative, smart economy and two relate to sustainable neighbourhoods and communities.

Dublin City Council has pledged to work with the Dublin Transport Authority and relevant transport agencies in the delivery of national transport infrastructure plans and infrastructural improvements through which the transport system in the Greater Dublin Area will be developed.

The plan also contains many specific guidelines, definitions and examples that explain how specific developments should be pursued in the city. This guidance is intended to make clear to any person interested in development in the city, what is required in order to meet the goals of the Development plan.

In the development plan Dublin City Council undertakes it will actively pursue a leadership role to foster collaboration and it will seek to develop new networks with agencies and other stakeholders with a view to successfully implement the policies and objectives of the plan.

5 Future Development and Collaboration

Previous links between GSI and Dublin City Council (and other local authorities) have proved fruitful in informing land-use guidelines for a range of geological phenomenon. New links between the Geological Survey of Ireland and Dublin City Council should be explored to bring societal benefits of geological information to a wider stakeholder base. The Dublin City Development Plan presents the opportunity to create new links with Dublin City Council and the experience gained from interactions with other similar bodies will assist in maximising the benefits from any alliance.

The comprehensive detail available in the National Geotechnical Borehole Database makes it a great source of information that is already widely used by industry to understand the underground in Dublin City centre and this data source is in the process of being transformed into a useable 3D model and related products.

Dublin City Council (along with NAMA) is one of the largest land owners in the City. Dublin City Council commissions many infrastructure and domestic building projects, most of which are obliged to carry out detailed geological investigations prior to siting and construction works. A formal connection with Dublin City Council will help both parties as GSI can provide information to the Council and the Council can return valuable subsurface data to the GSI.

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Sub-Urban

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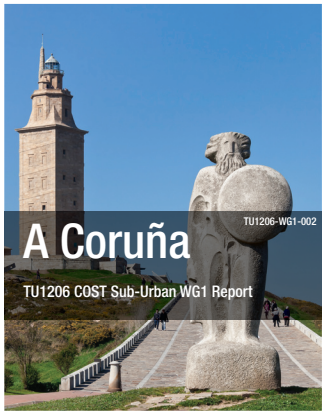
OUT OF SIGHT OUT OF MIND?

Considering the subsurface in urban planning - State of the art

TU1206 COST Sub-Urban WG1 Report

Michiel J. van der Meulen, S. Stjernqvist G. Campbell, David J. Lawrence,
Rubén C. Lois González, Ignace P.A.M. van Campenhout



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A Coruña

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TU1206-WG1-003

Bergen

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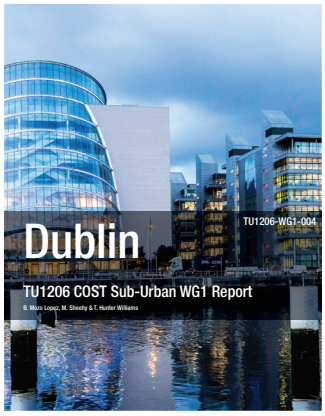
A. Solheim & K. Gammeltoft, H. de Beer, F. Molde & I. Eriksson



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Dublin

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B. Mota Lopez, M. Sheehy & T. Hunter Williams

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Glasgow

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K. Whitbread, G. Dick & D. Campbell

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Hamburg

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R. Saga, L. Moosmann, N. Clisson & P. Meyer

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Helsinki

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O. Bulovsky, I. Salula & R. Heinonen

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Ljubljana

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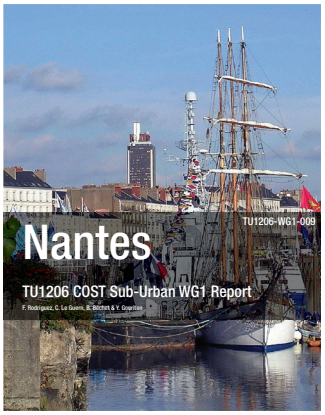
M. Janza & I. Stanc



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Nantes

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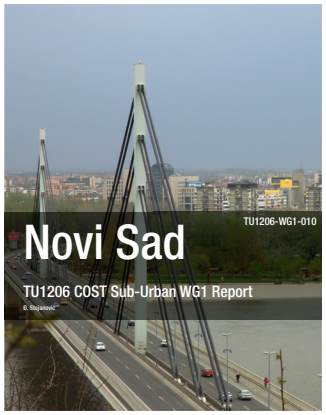
F. Rodriguez, C. Le Guern, JE. Béchet & Y. Gognies



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Novi Sad

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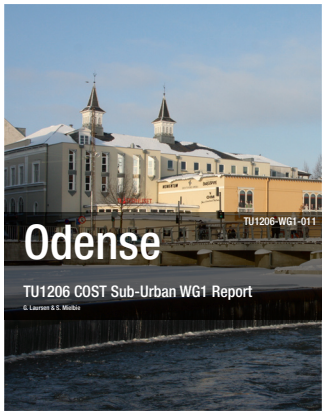
B. Stojanovic



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Odense

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G. Laursen & S. Mielbe

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Oslo

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I. Eriksen, J. Borchgrevink, M. M. Sattler, H.K. Dønhnes, S. Adamgu & L. Andrigsen

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Rotterdam

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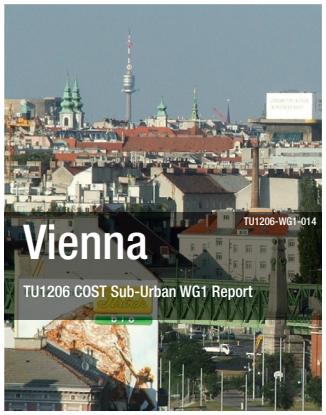
I. van Campenhout, R de Vette, J. Schokker & M van der Meulen



TU1206-WG1-014

Vienna

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