12 Soils, Geology, Hydrogeology and Hydrology

12.1 Introduction

This chapter on soils, geology, hydrogeology and hydrology provides a description of the existing geology, hydrogeology and hydrology in the study area of the Proposed Project and its immediate surroundings. The chapter also describes and assesses the likely impacts on the soils, geology, hydrogeology and hydrology associated with both the construction and operational phases of the Proposed Project.

Potential impacts of the Proposed Project are identified and residual impacts are described. The chapter initially sets out the assessment methodology used, describes the available baseline data for the existing environment and examines the potential impacts of the proposal and associated mitigation measures.

12.2 Study Area

The focus of the site specific studies comprises the proposed extent of the study area as presented on **Figure 12.1**.

In addition, for the purpose of assessment the impacts of the Proposed Project on the surrounding environment, the wider study area includes up to a 2km radius from the site. The extent of the wider study area was based on the IGI guidelines which recommend a minimum distance of 2km. It is considered that the scale of the Proposed Project does not necessitate a larger study area.

12.3 Guidelines and Sources

12.3.1 Soils, geology and hydrogeology

This chapter has been prepared in accordance with guidelines from the Environmental Protection Agency (EPA) and the Institute of Geologists of Ireland (IGI):

- IGI (2013) *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*.
- EPA (2015) *Revised Guidelines on the information to be contained in Environmental Impact Statements, Draft 2015.*

Data used in the baseline study was collected from the following available sources:

- Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie)
- Groundwater quality status maps (watermaps.wfdireland.ie)
- Teagasc Subsoils map (gis.epa.ie/Envision)
- Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision)

- Geological Heritage Areas, GSI
- Protected areas, Biodiversity Ireland (maps.biodiversityireland.ie)
- Integrated Pollution Control (IPC) and Industrial Emissions (IE) Licences, EPA
- Historic Maps from the Ordnance Survey of Ireland (www.osi.ie)

12.3.2 Hydrology

This chapter has been undertaken in accordance with *The Planning System and Flood Risk Management – Guidelines for Planning Authorities* published in 2009 jointly by the Office of Public Works (OPW) and the Department of Environment, Heritage and Local Government (DEHLG) as well as Dublin City Development plan (2016-2022).

Data used in the baseline study was collected from the following available sources:

- National Flood Hazard Mapping, OPW (floodmaps.ie);
- Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie);
- Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision);
- Flood history of the site from the OPW National Flood Hazard Mapping website (www.floodmaps.ie);
- Catchment Flood Risk Assessment and Management (CFRAM) Mapping produced by the OPW (map.opw.ie/floodplans);
- Preliminary Flood Risk Assessment (PFRA) Mapping produced by the OPW (www.cfram.ie/pfra);
- Predicted extreme water levels and flood extent maps from the ICPSS;
- Site Geological and hydrogeological data from the Geological Survey of Ireland website (www.gsi.ie);
- Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG);
- Aerial photography and mapping from Bing Maps and Google Maps.

Water resource management in Ireland is dealt with in the following key pieces of legislation which were taken into consideration in this assessment:

a) The EU Water Framework Directive (WFD), 2000/60/EC;

b) The Groundwater Directive, 2006/118/EC;

c) European Communities (Water Policy) Regulations 2014 (S.I. No. 350 of 2014);

d) European Communities Environmental Objectives (Groundwater) Regulations 2016 (S.I. No. 366 of 2016);

e) European Communities Environmental Objectives (Surface Water) Regulations 2015 (S.I. No. 386 of 2015);

f) European Communities (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014);

g) European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. No. 293 of 1988);

h) Water Services Acts (2007 – 2014);

i) The EU Floods Directive, 2007/60/EC.

12.4 Assessment Methodology

The potential impact of the Proposed Project on the soils, geological hydrogeological and hydrological environment has been assessed by classifying the importance of the relevant attributes and quantifying the likely magnitude of any impact on these attributes.

This impact assessment methodology is in accordance with the guidance outlined in *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements* published by the Institute of Geologists of Ireland (IGI) in 2013.

This document outlines a 13 step methodology, which has four distinct elements, as follows:

- Element 1: Initial Assessment (Steps 1 to 5)
- Element 2: Direct and Indirect Site Investigation and Studies (Steps 6 to 9)
- Element 3: Mitigation Measures, Residual Impacts and Final Impact Assessment (Steps 10 to 12)
- Element 4: Completion of the Soils, Geological and Hydrogeological Sections of the EIS (Step 13)

The initial assessment as outlined in **Section 12.5** describes the existing geological, hydrogeological and hydrological environment and presents a description of the past and present uses of the site and other neighbouring sites. This section also describes the nature of the site based on both site specific and neighbouring site investigation data from publicly available sources.

Where specific features e.g. quarries etc. are identified, their importance is ranked in line with the IGI Guidelines. These criteria are presented in **Appendix 12.1**.

The outcome from examining this available data is the Conceptual Site Model (CSM) which is briefly outlined in **Section 12.5.6**.

Section 12.7 lists the predicted impacts associated with the development of the site. The magnitude of the potential impact is ranked in accordance with the IGI Guidelines (**Appendix 12.1**) and this allows the Significance of the Impact (**Appendix 12.1**) to be determined.

Following the assessment of impacts, specific mitigation measures have been developed to avoid, reduce and, if possible, remedy any negative impacts on the soils, geology, hydrogeology and hydrology. These are described in **Section 12.8** below.

Residual impacts are described in **Section 12.9**. The magnitude and significance of these residual impacts have also been classified based on the IGI Guidelines (presented in **Appendix 12.1**).

12.5 Baseline Environment

12.5.1 Site Location and Setting

The Proposed Project is located in Dublin City centre and covers an area of 1.4 Ha The site extends from Dame Street to Lower Grafton Street and is located in an entirely built-up urban environment surrounded by residential and commercial buildings as well as historic buildings (**Figure 12.2)**.

The closest rivers to the site are the River Liffey, located approximately 0.2km to the north, and the River Dodder, located approximately 2km to the east of the site. The Grand Canal is located approximately 1.3km south east of the site and Dublin Bay is located approximately 3km to the east.

Appendix 12.2 shows the historical setting of the area between 1709 to the present day. The site use has The OSI historical map, available on the OSI web page (www.osi.ie), provides 6" (1827 to 1841) and 25" (1897 to 1931) maps of the area. These indicate that the land has been a part of an urban environment for the last two centuries. The perimeter of the study area has been surrounded by the Bank of Ireland building (previously Ireland's Parliament House) on its northern side, Trinity College Dublin to its eastern side and a series of buildings to the south.

The study area is flat with little to no topographic variations. Based on borehole logs available from the GSI Geotechnical Data Viewer for an area adjacent to the site the ground level is approximately 6 mOD. The ground level gently falls towards the River Liffey and rises in the south towards the Grand Canal.

The study area is surrounded by an urban environment including a large proportion of hard standing and buildings with some green unpaved areas.

12.5.2 Soils and Geology Baseline Environment

12.5.3 Regional Soil and Subsoil

According to the Teagasc soils map Made Ground dominates the upper soils and subsoils in the region (**Figure 12.3** and **Figure 12.4).** Made Ground is a term which refers to soil which has either been altered or placed by man. The presence of Made Ground along the Proposed Project and across the study area is consistent with what is expected in a built-up urban environment. Other subsoils in the region further away from the city centre, and which are likely to underlie

the made ground, includes Carboniferous Limestone Till, alluvium sediment and glaciofluvial sands and gravels derived from limestone.

12.5.4 Regional Bedrock Geology

The bedrock underlying Dublin City is the Lower Carboniferous basinal limestones and shale known as Calp **(Figure 12.5)**. The formations consists of dark grey massive limestones, shaley limestones with massive mudstones and chert common. The Geological Survey of Ireland (GSI) describes the bedrock geology underlying the Proposed Project as dark-grey argillaceous and cherty limestone and shale. No large-scale cavities have been observed in the Calp limestone.

12.5.5 Site Specific Soils and Geology

Information from previous ground investigations in the study area and its immediate vicinity have been attained from the GSI Geotechnical Data Viewer as well as an internal database of site investigations (**Figure 12.6**). A summary of the strata proven in the vicinity of the site is presented in **Table 12.1**. The borehole logs are available from the Geological Survey Ireland Spatial Resources Viewer (www.gsi.ie).

Borehole logs to the south of the site shows that the ground consists of Made Ground overlying dominantly hard brown to black clay with occasional layers of gravel and setts overlying bedrock. The proven depth to bedrock (with rotary drilling) ranges from approximately 3mbgl to 4mbgl (**Table 12.1**).

Table 12.1 - Soils and geology in the study area from previous site investigations

Depth to top of stratum (mbgl)	Stratum description	Thickness (m)
0	Fill – Made ground	0.5-2.4 (where present)
0-4.0	Brown clay	0.5-2.4 (where present)
0.2-6.1	Hard black clay	0.8-1.5
3.2-4.3	Limestone bedrock, Calp	Unproven

12.5.6 Contaminated land

The National Waste Collection Permit Office (NWCPO) issue Waste Collection Permits for all of the Waste Management Regions in Ireland. According to the EPA Envision map viewer, there are no waste licenced facilities or IPC or IE facilities within 500m and the closest facility is located approximately 1km from the site.

Considering that the location of the site has been in an urban environment for centuries, and is currently in an area of high traffic volumes, it is possible that there is soil contamination at the site.

12.5.7 Hydrogeology Baseline Environment

12.5.8 Regional Hydrogeology

The Geological Survey of Ireland has devised a system for classifying the aquifers in Ireland based on the hydrogeological characteristics, size and productivity of the groundwater resource. The three main classifications are Regionally Important Aquifers, Locally Important Aquifers and Poor Aquifers.

The bedrock underlying the study area is classified by the GSI as a Locally Important Aquifer which is productive only in local zones (Ll) and belongs to the Dublin Groundwater Body (**Figure 12.7**). Locally Important aquifers are dominated by poor yielding boreholes with yields less than 40 m^3/d Kelly *et al*. (2015). Notwithstanding its designation the groundwater is recorded as being abstracted from the limestone bedrock at yields of up to 393 m^3/d located 900m from the site on the north side of the River Liffey (GSI 2016).

The aquifer is not considered to have any primary porosity and flow is likely to occur through fractures and fissures. The transmissivity of the aquifer is reported to be generally low (1-10 m^2/d) and decreases significantly with depth (GSI n.d.). Most groundwater flow will take place close to the surface or along fractures and fissures at greater depths (GSI n.d.).

The GSI described the general groundwater flow direction of the Dublin groundwater body to be from west to east towards the coast and also towards the River Liffey (GSI n.d.).

The locally important aquifer is considered to be of medium importance according to the IGI guidelines.

12.5.9 Groundwater vulnerability

Aquifer or groundwater vulnerability is a relative measure of the ease with which the groundwater could be contaminated by human activity and depends on the aquifer's intrinsic geological and hydrogeological characteristics. The vulnerability is determined by the permeability of any overlying deposits. For example, bedrock with a thick, low permeability, clay-rich overburden is less vulnerable than bedrock with a thin, high permeability, gravelly overburden.

The GSI uses five groundwater vulnerability categories – Extreme rock at or near surface or karst (X), Extreme (E), High (H), Moderate (M) and Low (L) for mapping purposes and in the assessment of risk to ground waters. The classifications are based on the thickness and permeability of the sub-soils overlying the aquifer.

The GSI has classified the aquifer vulnerability underlying the site as Medium to High in the western side of the site and Extreme in the eastern part of the site (**Figure 12.8**). However, based on rock head level it is more likely to be Extreme and at risk from pollution.

12.5.10 Recharge

The effective rainfall is 302 mm/yr across the site and the recharge coefficient, which is the proportion of effective rainfall to recharge groundwater, is 20% (GSI 2016). Effective rainfall is the amount of rainfall available as either recharge to ground or run-off to surface water after evaporation or taken up by plants.

Recharge is the amount of rainfall that replenishes the aquifer. It is a function of the effective rainfall, the permeability and thickness of the subsoil and the aquifer characteristics. According to GSI the recharge to the bedrock is 60 mm/yr across the site (**Figure 12.9**). Due to the nature of the ground cover at the site this is likely to be an overestimation as practically all the rainfall will be captured by the surface water collection system.

12.5.11 Site Hydrogeology

Site investigation data which includes groundwater levels is not currently available for the study area.

The hydraulic conductivities of the units is unknown, however the clay is expected to be low, in the order of 10^{-11} to 10^{-9} m/s (Domenico and Schwartz 1998) while the hydraulic conductivity in the limestone is expected to be moderate, in the 10^{-9} to 10^{-5} m/s (GSI 2015).

Based on experience in the area water likely to be encountered at the base of the made ground, between 2-4mbgl, however this is unlikely to be groundwater and is more a reflection of rainfall which cannot drain quickly enough through the low permeability till.

12.5.12 Groundwater Quality

Under the requirements of the Water Framework Directive, the Dublin groundwater body was classified as having an overall good status for water quality and quantity 2010-2015. However, it is classified as ‘at risk’ of not achieving at least good ecological or good chemical status/potential by 2015.

No site specific water quality data is available.

12.5.13 Hydrology Baseline Environment

The study area is located within Hydrometric Area 09 (HA 09) which is the EPA classification for the catchments flowing into Dublin Bay. This hydrometric area falls within the Eastern River Basin District (ERBD). The principal catchments are the Liffey, Tolka and Dodder River catchments and their associated sub-catchments. Consultation of the EPA online Envision mapping showed that there are no rivers or streams at the site of the Proposed Project.

Hydrometric Area 09 is 1,616 km² in size with a maximum elevation of 338 m OD and a mean slope of 2.9% and is the most densely populated hydrometric area in Ireland.

The study area is in the catchment area for the River Liffey which contains the largest tract of continuous and discontinuous urban fabric in the country, which is approximately 21% of the hydrometric area while, agricultural land comprises more than 60% of the area. As the area is a rapidly expanding urban zone, the main driving forces are population growth, industrial production, agricultural production, transportation, and energy demand and consumption. Consequently, these driving forces cause a number of pressures to exert negative impacts on water bodies and the larger natural environment including sources of diffuse pollution and point source pollution.

Environmental pressures present in HA09 include:

- Diffuse sources;
- Point sources;
- Transport;
- Waste management; and
- Recreation and tourism.

Surface Water Bodies

Surface water bodies that are considered to be relevant to the Proposed Project include the River Liffey, Grand Canal and Dublin Bay (**Figure 12.1**).

River Liffey

The Liffey River rises between Kippure and Tonduff in the Wicklow mountains, and flows for approximately 125 km through counties Wicklow, Kildare and Dublin before entering the Irish Sea at its mouth at the mid-point of Dublin Bay, on a line extending from the Baily lighthouse to the Muglin Rocks. It is located approximately 0.2km north of the study area. The Liffey River is a controlled river that has a regulated flow. There are three ESB hydroelectric power stations along the river, at Poulaphouca, Golden Falls and Leixlip, as well as a number of minor private installations. Major reservoir facilities also exist at Poulaphouca where significant waterfalls there and at Golden Falls were flooded by reservoir construction. The annual average flow of the Liffey River at Leixlip is approximately 2.35 m^3/s. Low flow conditions are maintained at 2.00 m^3/s (Fingal, 2005).

Grand Canal

The Grand Canal is a manmade waterway that links the River Liffey with the Shannon at Shannon Harbour and the Barrow at Athy. It is located approximately 1.4km east of the site. The Grand Canal system is designated as a proposed Natural Heritage Area (pNHA) under national legislation which comprises the canal channel and the banks of either side of it. There are various habitats within the canal system including hedgerow, tall herbs, calcareous grassland, reed fringe, open water, scrub and woodland. The ecological value of the canal lies within the diversity of species rather than the presence of rare species (NWPS, 2015).

Dublin Bay

South Dublin Bay, located less than ten metres to the south east of the site, is designated both as a Special Area of Conservation (SAC) and a Special Protection Area (SPA). The features of interest of the South Dublin Bay SAC include mudflats and sandflats not covered by seawater at low tide, annual vegetation of drift lines, salicornia and other annuals mud and sand and embryonic shifting dunes (NPWS, 2013). The SAC overlaps with South Dublin Bay and River Tolka Estuary SPA. The SPA is associated with site-specific conservation objectives aiming to preserve natural habitats for a number of species (NPWS, 2015).

12.5.14 Surface Water Quality

The Liffey is classified as a nutrient sensitive water body and is considered to be at high risk from diffuse pollution through groundwater and urban run-off and from point sources located within its catchment (ERBDA, 2005). Refer to Chapter 9 '*Biodiversity*' for further detail on the status of the River Liffey.

According to EPA mapping, the River Liffey has WFD status of 'Good' (2010 – 2012). It has also been classified as being "*at risk of not achieving good status in 2015"*.

The EPA conducts regular water quality assessments for both physical-chemical and biological water quality at various locations along the River Liffey. The monitoring stations that are in closest vicinity to the Proposed Project are (1000) 2.5 km d/s Newbridge and (1050) Victoria Bridge. Water quality sampled at these sampling points is presented in **Table 12.2**.

Table 12.2 - River Liffey Biological Quality Ratings (EPA, 2013)

Biological Quality Rating (Q Value)							
Station	**Year**						
	1995	**1998**	**2002**	**2005**	**2007**	**2010**	**2013**
1000	4	4-5	4	4	4	4	4
1050	4	4	4	4	4	4	-

12.5.15 Flood Risk

The following planning policy documents are relevant to the assessment of the Proposed Project in terms of flood risk:

- The Planning System and Flood Risk Management Guidelines for Planning Authorities' published by the OPW and the Department of the Environment, Heritage and Local Government in November 2009; ';
- The Dublin City Council Development Plan 2016–2022.

Refer to **Appendix 12.3** (Flood Risk Assessment) for detailed discussion of these policy documents.

In broad terms, the potential sources of flooding at the site can be categorised as:

- Fluvial (River) Flooding;
- Tidal/Coastal Flooding;

- Pluvial Flooding;
- Groundwater Flooding;

Each of these potential sources of flooding are considered in this section.

It is noted that from an examination of historical records on OPW's National Flood Hazard Mapping Website (floodmaps.ie) there is no record of historic flooding in the study area.

12.5.16 Fluvial Flood Risk

The Eastern CFRAM fluvial flood extent map for the 10% 1% and 0.1% Annual Exceedance Probability (AEP) events for the site is presented in **Figure 12.10**. It can be seen that the study area is located outside of the predicted fluvial floodplain. The risk of fluvial flooding is therefore very low.

The River Stein runs to the front of Trinity College Dublin (**Figure 12.11)**. This watercourse, which has been incorporated into the public sewerage system since the early 1900's through a series of underground culverts, runs approximately 2.5km from Charlemont Bridge downstream to the River Liffey.

Based on an inspection of aerial imagery and from site visits, it can be concluded that the Stein is culverted throughout its reach. There are no open channel sections which offer a route for water to flood the surrounding area. The risk of fluvial flooding from the culvert is therefore limited to the potential for surcharging at the culvert entrance and pressurised flow within the culvert forcing water out through any connecting back pipes, manholes or connecting culverts.

The catchment area upstream of the River Stein culvert is likely to be very small

given the close proximity of the Dodder, Poddle and Gallows Stream catchments.

The risk of the culvert entrance being surcharged due to high flows is therefore likely to be low. It can therefore be concluded that surcharging of the culvert entrance is unlikely to present a significant risk of flooding to the project site.

In the absence of data on the culvert close to the subject site, the risk of flooding arising from pressurised flow within the culvert cannot be accurately determined. Given the absence of any record of historic flooding of the site, it is likely that this risk of flooding is low.

Coastal Flood Risk

Two separate studies have been undertaken in recent years which provide predicted coastal extents and design maximum water levels for Dublin:

- Eastern CFRAM Study;
- Irish Coastal Protection Strategy Study (ICPSS);

Both have been reviewed to determine the risk of flooding of the site.

Figure 12.12 presents an extract from the Eastern CFRAMS showing the coastal flood extents for the 10%, 0.5% and 0.1% AEP events. It can be seen that the site is located outside the 0.1% AEP flood extent.

Figure 12.13 presents the flood depth map for the 0.5% AEP coastal flood extent from the ICPSS. It can be seen that the College Green site is not located within the predicted flood extent.

Topographical data for the study area indicates that the ground levels at the site are circa 6m O.D. The 1 in 200 year (0.5% AEP flood event) tidal flood level as predicted by the Eastern CFRAM Study is 3.12m O.D which is significantly below the existing ground.

The risk of coastal flooding to the site is therefore very low.

Pluvial Flood Risk

Pluvial flooding occurs when extreme rainfall overwhelms drainage systems or soil infiltration capacity, causing excess rainwater to pond above ground at low points in the topography.

Two separate studies have been undertaken in recent years which considered the risk of pluvial flooding to Dublin:

- Flood Resilient City Project undertaken by Dublin City Council;
- PFRA maps;

Both have been reviewed to determine the risk of flooding of the site.

Figure 12.14 presents the pluvial flood extent from the Flood Resilient City. It can be seen from the figure that the College Green site is indicated as being at risk of pluvial flooding.

Figure 12.15 presents the flood extents for the 1% and 0.1% AEP pluvial events from the PFRA. It can be seen that a small area of the site is indicated as being at risk of pluvial flooding.

It is noted that the pluvial flood extents as estimated in both studies and presented in **Figure 12.14** and **Figure 12.15** are different with the Flood Resilient City Project predicting a greater pluvial flood extent than the PFRA extent.

Based on the finding of both of these studies it can be concluded that there is a minor risk of pluvial flooding to the site.

The existing drainage regime of the area of the site is being retained as part of the Proposed Project. Additional new SuDS features however will be incorporated into the Proposed Project. These will consist of new attenuation/infiltration areas beneath proposed trees filled with crushed stone or soil.

New gullies will also be arranged so that overflow from these attenuation/infiltration areas will discharge to the piped surface water drainage system. All existing surface water collection points will be raised to suit proposed new ground levels.

The low risk of pluvial flooding to the site will be mitigated by the design of the surface water drainage network.

12.5.17 Groundwater Flood Risk

Groundwater flooding can occur during lengthy periods of heavy rainfall, typically during later winter/early spring when the groundwater table is already high. If the groundwater level rises above surface level, it can pond at local points and cause periods of flooding.

As stated in **Section 12.5.12**, there is no site investigation groundwater information available for the study area. However, based on experience in the area, water beneath the site is likely to be present at approximately 2-4mbgl, at the top of the boulder clay.

The risk of groundwater flooding is therefore considered to be low.

Anecdotal evidence however suggests that some basements in the vicinity of the works may have experienced groundwater ingress during the recent Luas Cross City works.

12.5.18 Sensitive features of the Baseline Environment

12.5.19 Groundwater resources

Groundwater is not used extensively for residential or industrial purposes in the area. **Table 12.3** summarises the groundwater abstractions recorded in the GSI database and the Dublin City Council abstraction archives within 2km of the site boundary. These are presented in **Figure 12.18**. No groundwater abstractions are located within the area of the Proposed Project.

The nearest groundwater abstraction is 350 m from the site on the opposite side of the River Liffey. This is not be assessed further as the River Liffey will act as a hydraulic barrier.

Table 12.3 - Groundwater abstractions within 2km of the study area

Borehole Name (GSI)	Easting	Northing	Type	Depth (m)	Location accuracy	Use	Yield (m^3/day)
2923SEW013	315400	234300	Borehole	106.7	To 200m	Unknown	114.5
2923SEW015	314750	234750	Borehole	30.4	To 500m	Industrial	393
2923SEW012	315950	235050	Borehole	137	To 100m	Unknown	163.6
2923SEW029	317420	234700	Borehole	6.5	To 100m	Other	
2923SEW030	317500	234720	Borehole	7.8	To 200m	Other	
2923SEW014	317540	233680	Borehole	9.8	To 200m	Industrial	261.8

12.5.20 Groundwater dependent ecological sites

The study area is located approximately 1.5km west of the Grand Canal which is designated as a Proposed Natural Heritage Area (pNHA) and approximately 3km from Dublin Bay which is designated as a Special Area of Conservation (SAC) and a Special Protected Area (SPA) (**Figure 12.1**).

The Grand Canal is unlikely to be hydraulically connected to the underlying groundwater body and therefore is not assessed further in this Chapter. Refer to Chapter 9 '*Biodiversity*' for further detail.

As Dublin Bay is located over 2km from the site, it is not considered likely to be impacted by activities within the site and therefore is not assessed further.

12.5.21 Hydrological sites

The River Liffey is the closest river to the site located 150m to the north. The River Liffey is not protected under national or international status.

12.5.22 Geological Heritage Areas

The GSI database shows that there are no geological heritage areas on the site. The closest geological heritage area is the River Poddle which is an underground river located approximately 0.36km from the Proposed Project (**Figure 12.10**).

No quarries are located within 2km of the study area.

12.5.23 Conceptual model

A conceptual site model was compiled showing the depth and extents of overburden, bedrock profile, location of surface water features and groundwater levels were compiled. The model is presented in **Figure 12.19**.

12.5.24 Summary of features of importance

The main features of importance uncovered on the site and in the study area are summarised in **Table 12.4.**

Table 12.4 - Features of importance

Feature	Importance	Criteria / Justification
Soil	Low	The soil is poorly drained and therefore has a low significance or value on a local scale.
Bedrock aquifer classified by the GSI as a Locally Important Aquifer which is productive only in local zones (Ll)	Medium	A locally important aquifer is considered to be of medium value on a local scale.

The River Liffey is a hydrological feature of importance. The IGI do not designate importance ranking to hydrological features. There is no proposed construction

adjacent to the river which may pose a risk from runoff of pollutants. Therefore, the River Liffey is not assessed further in this chapter. Refer to Chapter 9 '*Biodiversity*'.

12.5.25 Classification of environment

The generic type of geological/hydrogeological environment of the Proposed Project can be determined based on the IGI guidelines. The generic types of geological/hydrogeological environments include:

- Type A – Passive geological / hydrogeological environments e.g. areas of thick low permeability subsoil, areas underlain by poor aquifers, recharge areas, historically stable geological environments;
- Type B – Naturally dynamic hydrogeological environments e.g. groundwater discharge areas, areas underlain by regionally important aquifers, nearby spring rises, areas underlain by permeable subsoils;
- Type C – Man-Made dynamic hydrogeological environments e.g. nearby groundwater abstractions, nearby quarrying or mining activities below the water table, nearby waste water discharges to ground, nearby geothermal systems;
- Type D – Sensitive geological / hydrogeological environments e.g. potentially unstable geological environments, groundwater source protection zones, karst;
- Type E – Groundwater dependent eco systems e.g. wetlands, nearby rivers with a high groundwater component of base flow.

The study area is Type A as it is a passive geological/hydrogeological environment in which low permeability subsoil overlies a locally important aquifer and recharge is largely inhibited due to the presence of hard standing.

12.6 Characteristics of the proposal

The Proposed Project will involve the following activities during the construction phase which have the potential to impact the geological and hydrogeological features of importance:

- Excavations during the construction stage which will be up to 2.5 mbgl to link into existing utilities in the area. The excavations may encounter contaminated material.
- Storage of stockpiles during the construction phase
- Minor pumping may be required if groundwater is encountered during excavations, although this is expected to be very localised to the site. This groundwater may be contaminated.

During the operational phase the area will be an urban environment covered in hard standing. There are no perceived activities which pose a risk to the geological and hydrogeological features of importance.

The following assessments are required by the Activities/Environment Matrix in the Institute of Geologists of Ireland guidelines corresponding to the Proposed Project conditions (Type A):

- Earthworks; and
- Excavations of materials above the water table.

Table 12.5 outlines the investigations required by the IGI guidelines for a Type A Environment which should be undertaken on the Proposed Project, based on the environmental type and different activities which will be undertaken.

Table 12.5 - Details of works required under the IGI Guidelines for a Type A Environment and how they are to be undertaken on the Proposed Project

Work required under Activity and Environment Type Class A (based on IGI guidelines)	Details of Works completed on the Site
Earthworks	
Invasive site works to characterise the nature, thickness, permeability and stratification of soils.	Site Investigations completed as presented in **Section 12.5.5**
Excavation of materials above the water table	
Site works to characterise nature, thickness, permeability and stratification of soils and subsoils e.g. trial pits, augering.	Site Investigations completed as presented in **Section 12.5.5**
Site works to fully characterise the bedrock geology and in order to define the resource volume/weight according to the PERC Reporting Standard e.g. trenching, drilling, geophysics.	Not relevant. Bedrock will not be encountered
Works to determine groundwater level, quality, flow direction and gradient; e.g. monitoring in stand pipes, piezometers, or boreholes.	Site Investigations which include groundwater monitoring are not available within the site, however the expected groundwater levels have been described in **Section 12.5.11**

12.7 Potential impact of the Proposed Project

This section will describe the impacts associated with the Proposed Project before mitigation measures are applied.

Both direct and indirect impacts will be addressed for the construction and operation of the Proposed Project. The nature, extent and duration of the impacts will also be assessed.

12.7.1 Construction phase

During the construction phase the following activities may pose a potential impact:

- Excavation of inert soils,
- Excavation of made ground,
- Contamination of soils, and
- Contamination of groundwater.

12.7.2 Excavation of inert soils

Soil will be excavated as part of construction works resulting in a Permanent Negative impact on the soils. The anticipated maximum depth of excavation is a maximum of 2.5 metres below ground level in confined areas.

The magnitude of this impact is Negligible due to the impact on the attribute being insufficient in magnitude to affect either use or integrity of any of the important features (see **Appendix 12.1** for definitions).

12.7.3 Excavation of made ground

There is potential for excavation of made ground on site. The excavation of any hotspots of contamination will be a Permanent Positive impact on the soils environment. Therefore, the magnitude of this impact is Minor Beneficial due to a minor improvement to the attributes quality. As a result, the significance of this impact is not applicable for all important features.

12.7.4 Contamination of Soils

There is a potential risk of localised contamination from construction materials leeching into the underlying soils by exposure, dewatering or construction related spillages resulting in a Permanent Negative impact on the soils.

In the case of soils, the magnitude of this impact is Small Adverse as it may result in the requirement to excavate/remediate a small proportion of contamination or result in a low risk of pollution to the soils. As a result, its significance is Imperceptible for all important soils features (see **Appendix 12.1** for definitions).

12.7.5 Contamination of Groundwater

There is a potential risk of localised contamination of the groundwater due to construction activities i.e. construction spillages, leaks etc. resulting in a Permanent Negative impact on the groundwater.

The groundwater table is approximately 2-4 m bgl. The bedrock has been proven at 3.2 mbgl which is overlain by clay. This clay will limit the potential for contamination to infiltrate into the underlying aquifer. No excavations are anticipated to take place into the bedrock.

For these reasons, the impact is Negligible on the groundwater contained within the bedrock aquifer. As a result, its significance is imperceptible (see **Appendix 12.1** for definitions).

12.7.6 Flood risk

The Proposed Project will have no impact on floodplain storage and conveyance.

The Proposed Project will also not increase flood risk off site.

12.7.7 Application of the Flood Risk Management Guidelines

It is considered that the Proposed Project should be classed as a 'water compatible development' as per the vulnerability classification in **Figure 12.16**.

As indicated in **Section 2.1.2** of **Appendix 12.3**, the Proposed Project is not indicated as being within the 1,000 year fluvial or 1,000 year coastal/tidal floodplain. In accordance with the OPW's planning guidelines, the site therefore lies within Flood Zone C.

Figure 12.17 illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' Guidelines.

As the Proposed Project lies within Flood Zone C, a Justification Test is not required and it is necessary only to identify mitigation measures for any residual risks. This has been discussed in further detail in the Flood Risk Assessment in **Appendix 12.3**.

12.7.8 Flood Risk Assessment Conclusion

There is no historic record of flooding of the site.

The risk of both fluvial and tidal/coastal flooding to the site is remote. There is a minor risk of pluvial flooding to the site.

The risk of groundwater flooding is considered to be low. It is noted however that anecdotal evidence suggests that basements in the vicinity of the site may have experienced groundwater ingress during construction of the Luas Cross City works.

Access and egress routes to and from the site are highly unlikely to be compromised during flood events.

The Proposed Project will not have any adverse impact on floodplain conveyance and storage and will not increase the risk of flooding in the surrounding area.

The low risk of pluvial flooding to the site will be mitigated by the design of the surface water drainage network.

Based on the findings of this FRA and the application of the Flood Risk Management Guidelines, it is considered that the Proposed Project should be classed as a 'water less vulnerable development'. As the site lies within Flood Zone C, a Justification Test is not required.

12.7.9 Operational phase

The operational phase of the Proposed Project is predicted to have an overall neutral long-term impact on the soils, geology, hydrological and hydrology within the study area.

There will be a reduction in traffic within the area reducing the potential for associated hydrocarbons spills.

12.8 Mitigation Measures

12.8.1 Construction phase

A project-specific Construction Management Plan (CMP) will be prepared and submitted to the planning authority for approval. It will be maintained by the Contractor for the duration of the construction phase. The CMP will cover all potentially polluting activities and include an emergency response procedure. All personnel working on the site will be trained in the implementation of the procedures.

As a minimum, the CMP manual for the Proposed Project site will be formulated in consideration of the standard best practice. The CMP will include a range of site specific measures which will include:

- Earthworks operations shall be carried out such that surfaces shall be designed with adequate falls, profiling and drainage to promote safe run-off and prevent ponding and flooding.
- Run-off will be controlled to minimise the water effects in outfall areas.
- Good housekeeping (site clean-ups, use of disposal bins, etc.) on the site project.

In order to prevent the accidental release of hazardous materials (fuels, cleaning agents, etc.) during construction site activity, all hazardous materials will be stored within secondary containment designed to retain at least 110% of the storage contents. Temporary bunds for oil/diesel storage tanks will be used on the site during the construction phase of the Proposed Project. Safe materials handling of all potentially hazardous materials will be emphasised to all construction personnel employed during this phase of the Proposed Project.

Mitigation during the construction phase will include implementing best practice during excavation works to avoid sediment running into the drainage system which discharges to the River Liffey.

12.8.2 Operational phase

No mitigation measures are required during the operational phase.

12.9 Residual impacts

Upon application of the mitigation measures outlined in **Section 12.8** the magnitude of any impacts both in the construction and operational phase are Negligible as detailed in **Table 12.6** (see **Appendix 12.1** for definitions). As a result, the significance of all the impacts is Imperceptible.

Table 12.6 - Summary of residual impacts on the identified features of importance

Feature	**Soil**	**Bedrock aquifer classified by the GSI as a Locally Important Aquifer which is productive only in local zones (Ll)**
Importance	Low	Medium
Justification	Poorly drained soil	Locally important aquifer.
Magnitude	Small adverse	Negligible
Justification	a low risk of pollution to the soils	Results in impact on attribute but of insufficient magnitude to affect either use or integrity
Significance	Imperceptible	Imperceptible
Mitigation measure	Refer to Section 12.8	Refer to Section 12.8
Residual impact	Negligible	Negligible
Justification	Imperceptible	Imperceptible

12.10 References

Domenico, P.A. and Schwartz, F.W., 1998 Physical and chemical hydrogeology, Volume 1, University of Michigan: Wiley.

GSI (n.d.) Dublin GWB: Summary of Initial Characterisation.

GSI (2016) Data Downloads, available online, http://www.dccae.gov.ie/natural-resources/en-ie/Geological-Survey-of-Ireland/Pages/Data-Downloads.aspx.

Kelly, C., Hunter Williams, T., Misstear, B.M., Motherway, K., 2015. Irish Aquifer Properties – A reference manual and guide. Prepared on behalf of the Geological Survey of Ireland and the Environmental Protection Agency.

IGI Guidelines, Environmental Impact Assessment (2013), available online, http://igi.ie/assets/files/Codes%20and%20Guidelines/IGI%20Enviro%20Impact%202013.

Geological Survey Ireland (2016) *Spatial Resources Viewer* Available at: www.gsi.ie)

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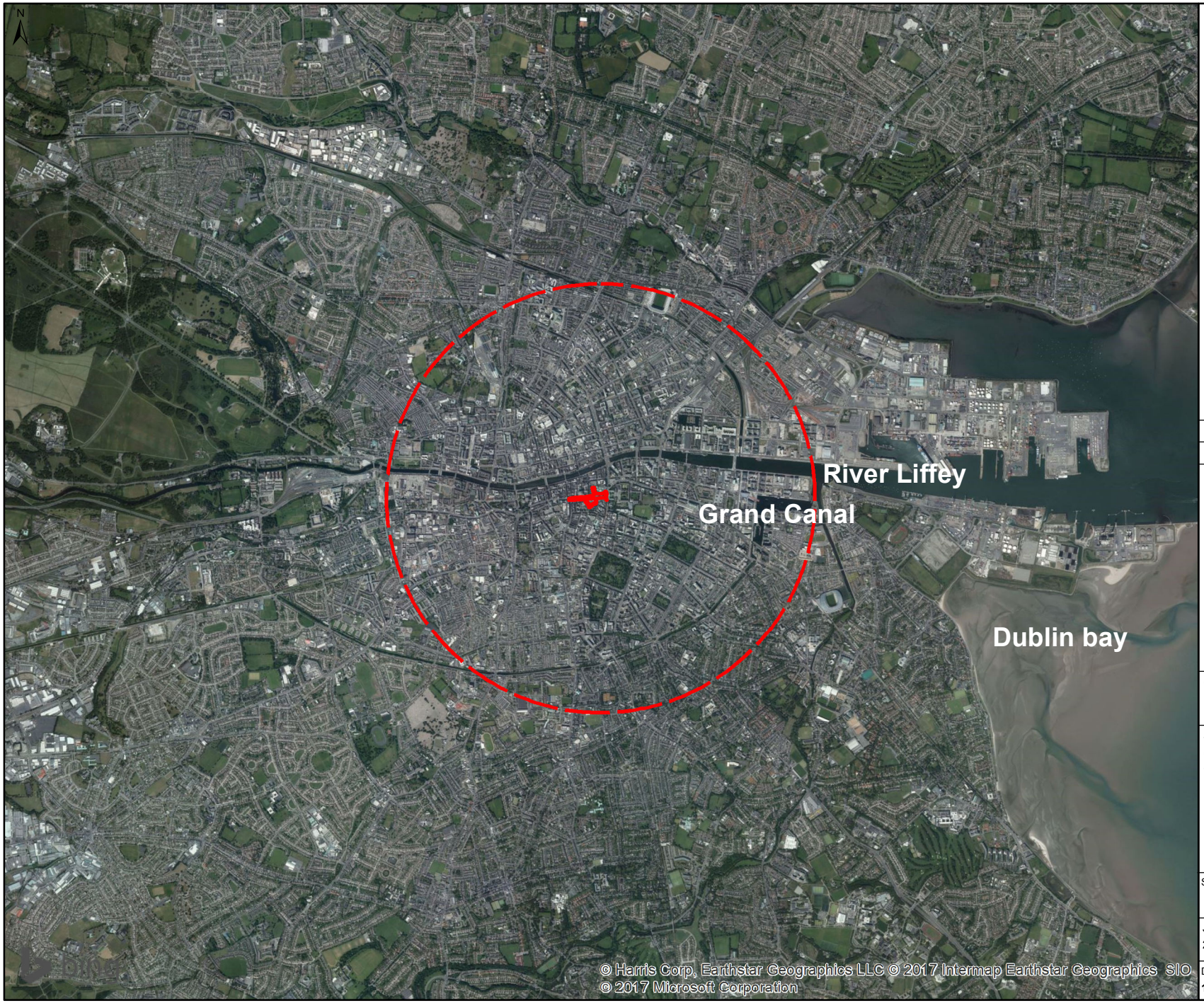

Legend

- Extent of main works
- 2km radius

Issue	Date	By	Chkd	Appd
D1	2017-01-20	JF	AO	CN

Kilometers

0 0.5 1 2

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Location of the study area

Scale at A4
1:50,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
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03/05/2017 09:57:29

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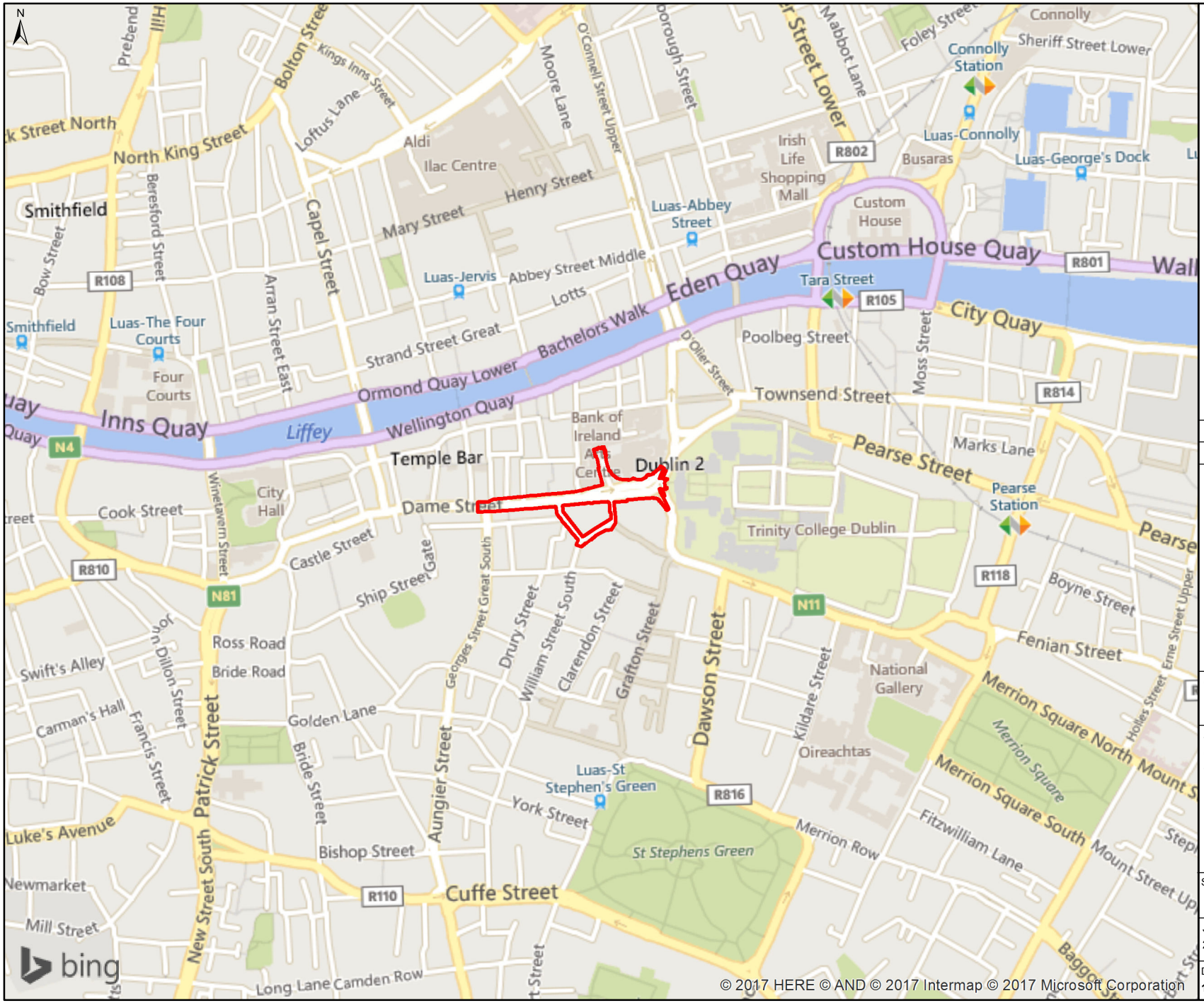

Legend

Extent of main works

Issue	Date	By	Chkd	Appd
F1	2017-01-20	JF	AO	CN

Kilometers

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Site setting

Scale at A4
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Job No	Drawing Status
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Drawing No	Issue
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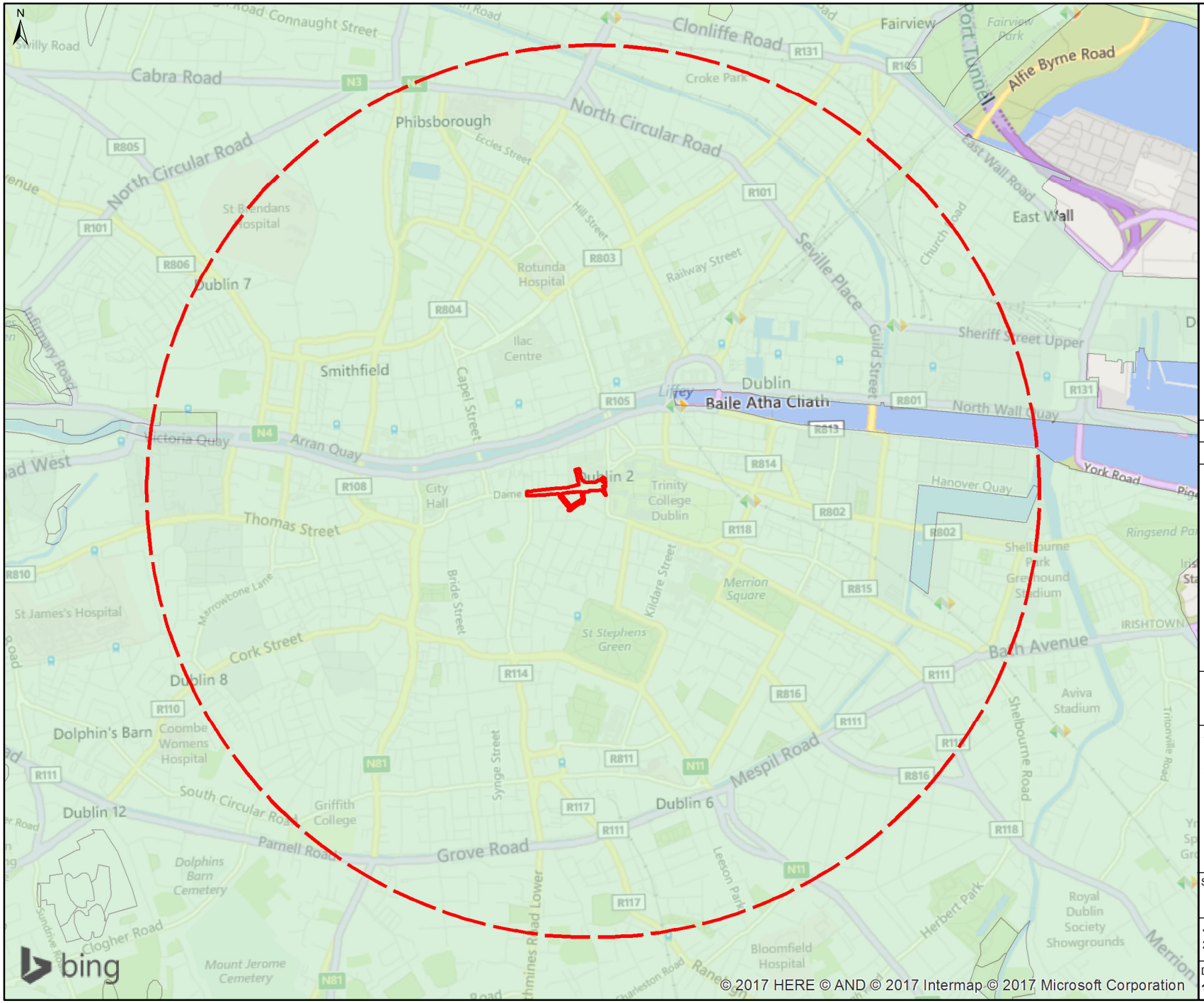

Legend

- Extent of main works
- 2km radius
- Made ground

Issue	Date	By	Chkd	Appd
D1	2017-01-20	JF	AO	CN

Kilometers

0 0.225 0.45 0.9

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Soils in the vicinity of the site

Scale at A4
1:24,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
12.3	**D1**

03/05/2017 09:34:09

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A4

Legend

- Extent of main works
- 2km radius
- Made ground

Issue	Date	By	Chkd	Appd
F2	2017-01-20	JF	AO	CN

Kilometers

0 0.225 0.45 0.9

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Subsoil in the vicinity of the site

Scale at A4
1:24,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
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03/05/2017 09:37:31

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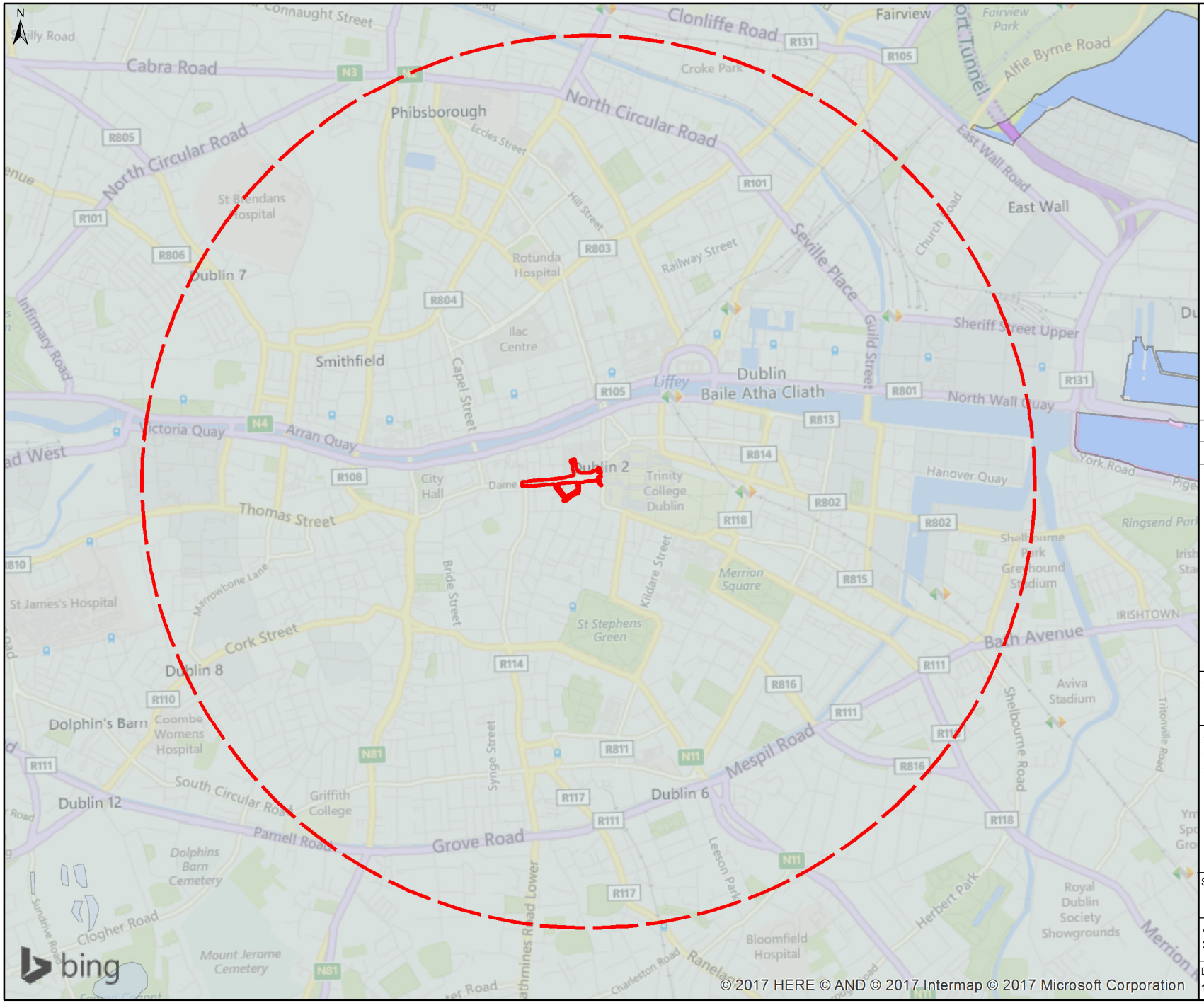

Legend

- Extent of main works
- 2km radius

Solid geology

- Calp

Issue	Date	By	Chkd	Appd
D1	2017-01-20	JF	AO	CN

Kilometers

0 0.225 0.45 0.9

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Solid geology in the vicinity of the study area

Scale at A4

1:24,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
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03/05/2017 09:36:00

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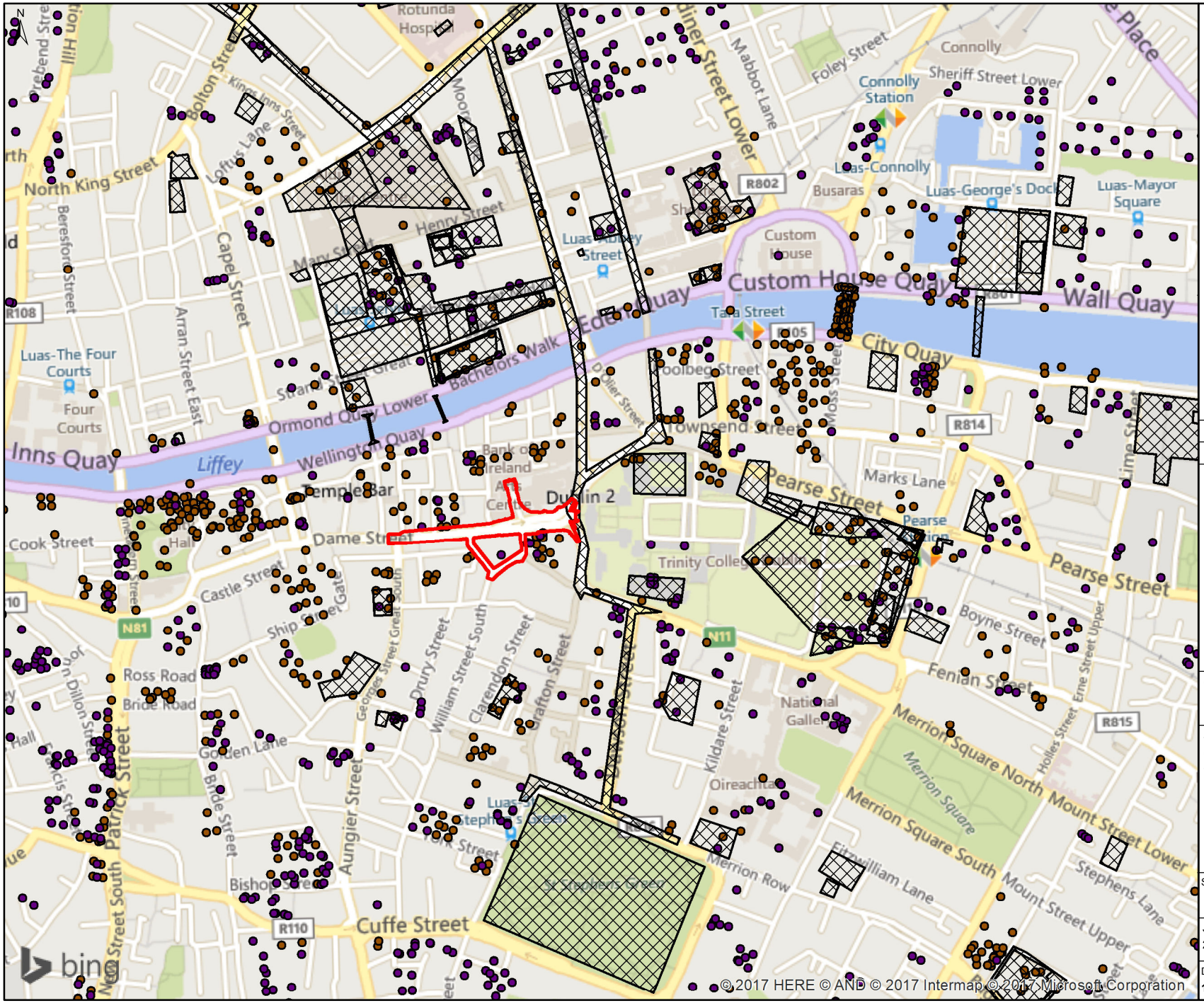

Legend

- Extent of main works
- Site Investigations (internal database)
- GSI boreholes (Bedrock not met)
- GSI boreholes (bedrock met)

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

Kilometers

0 0.075 0.15 0.3

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Previous site investigation locations

Scale at A4
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Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
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Legend

Extent of main works

2km radius

Bedrock aquifers

LI

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

Kilometers

0 0.225 0.45 0.9

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Bedrock aquifers in the vicinity of the study area

Scale at A4

1:24,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
12.7	**P0**

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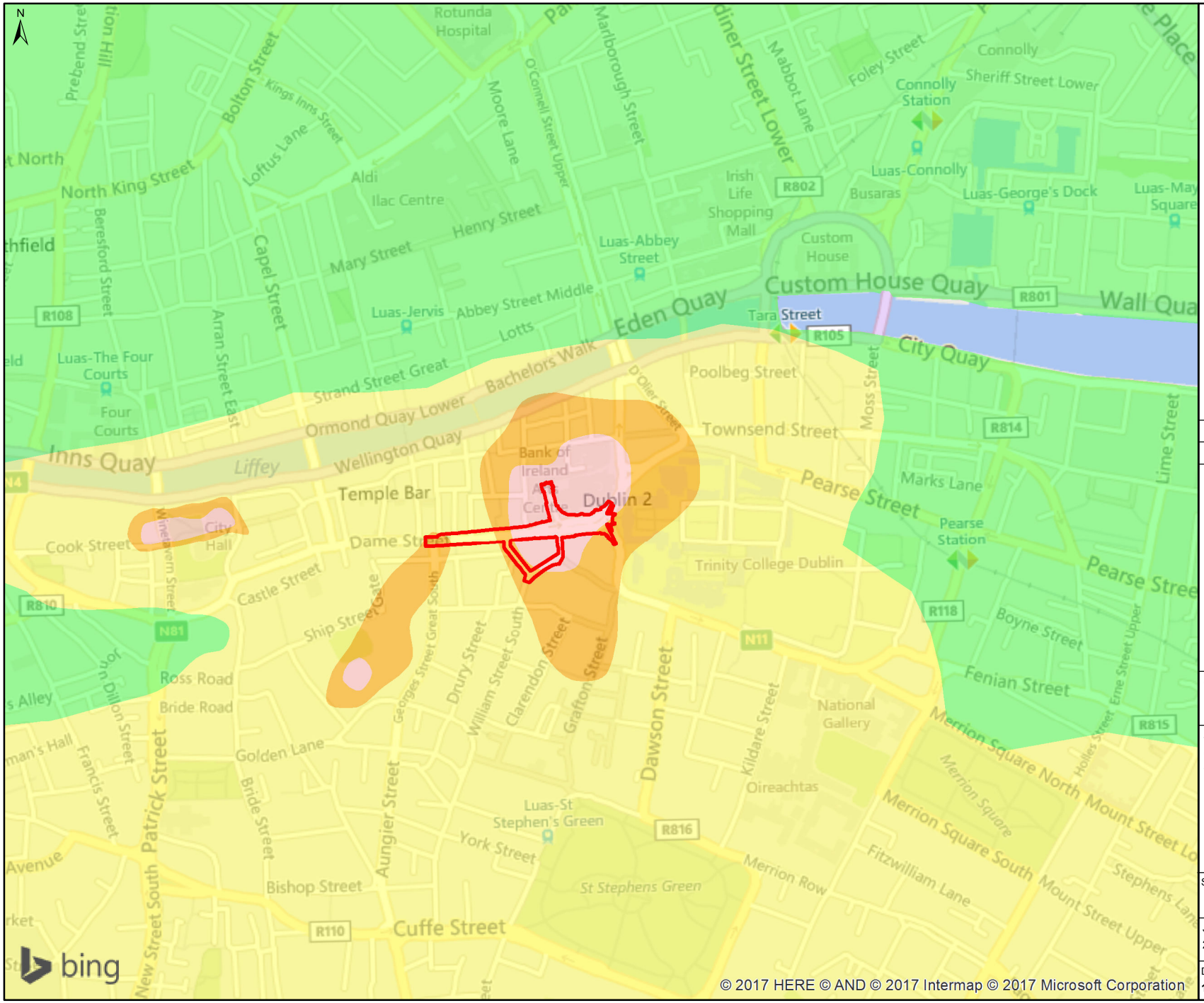

Legend

- Extent of main works
- Extreme
- High
- Medium
- Low

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

Kilometers

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Groundwater vulnerability

Scale at A4
1:10,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
12.8	**P0**

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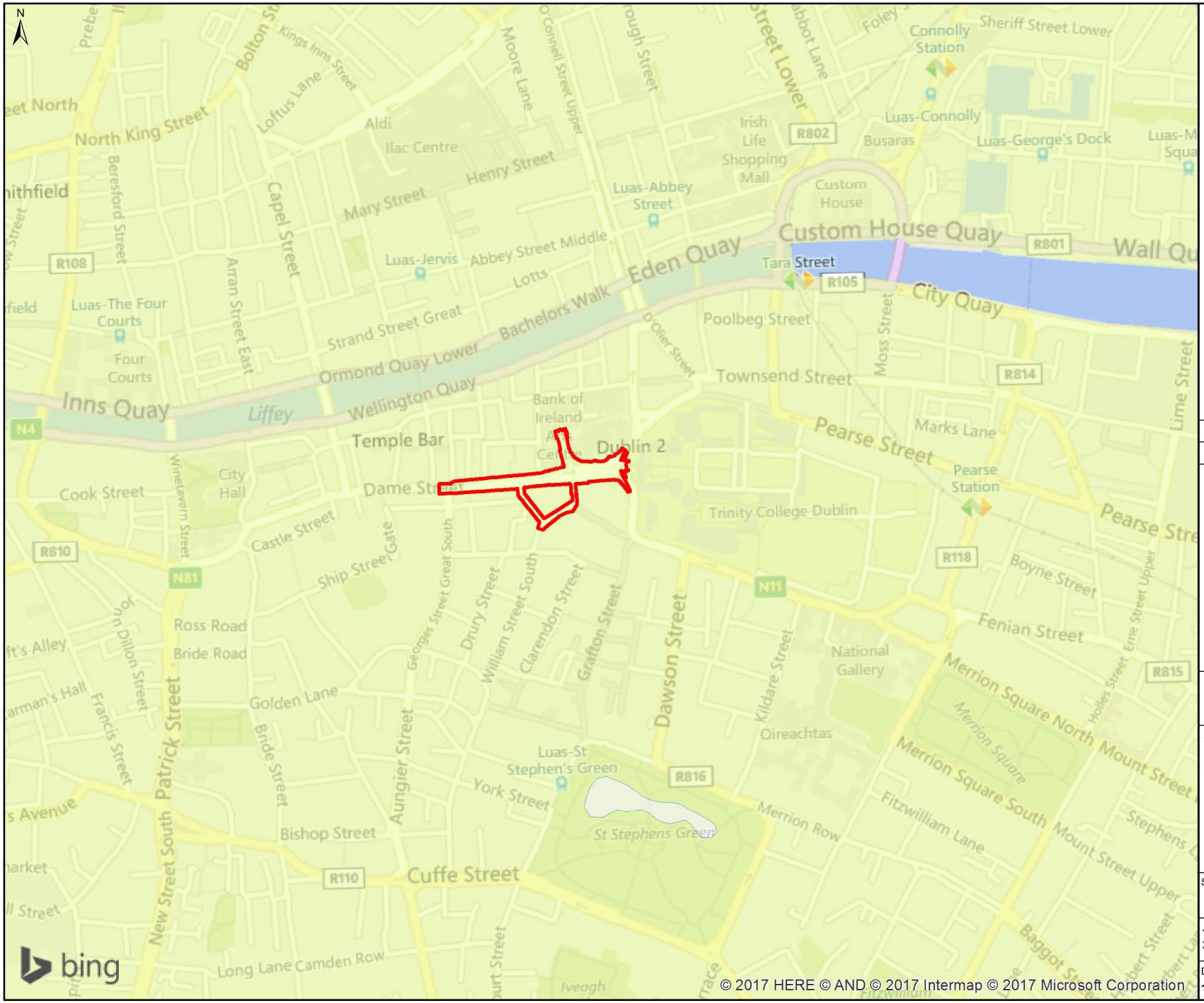

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Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

Kilometers

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Groundwater recharge

Scale at A4
1:10,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
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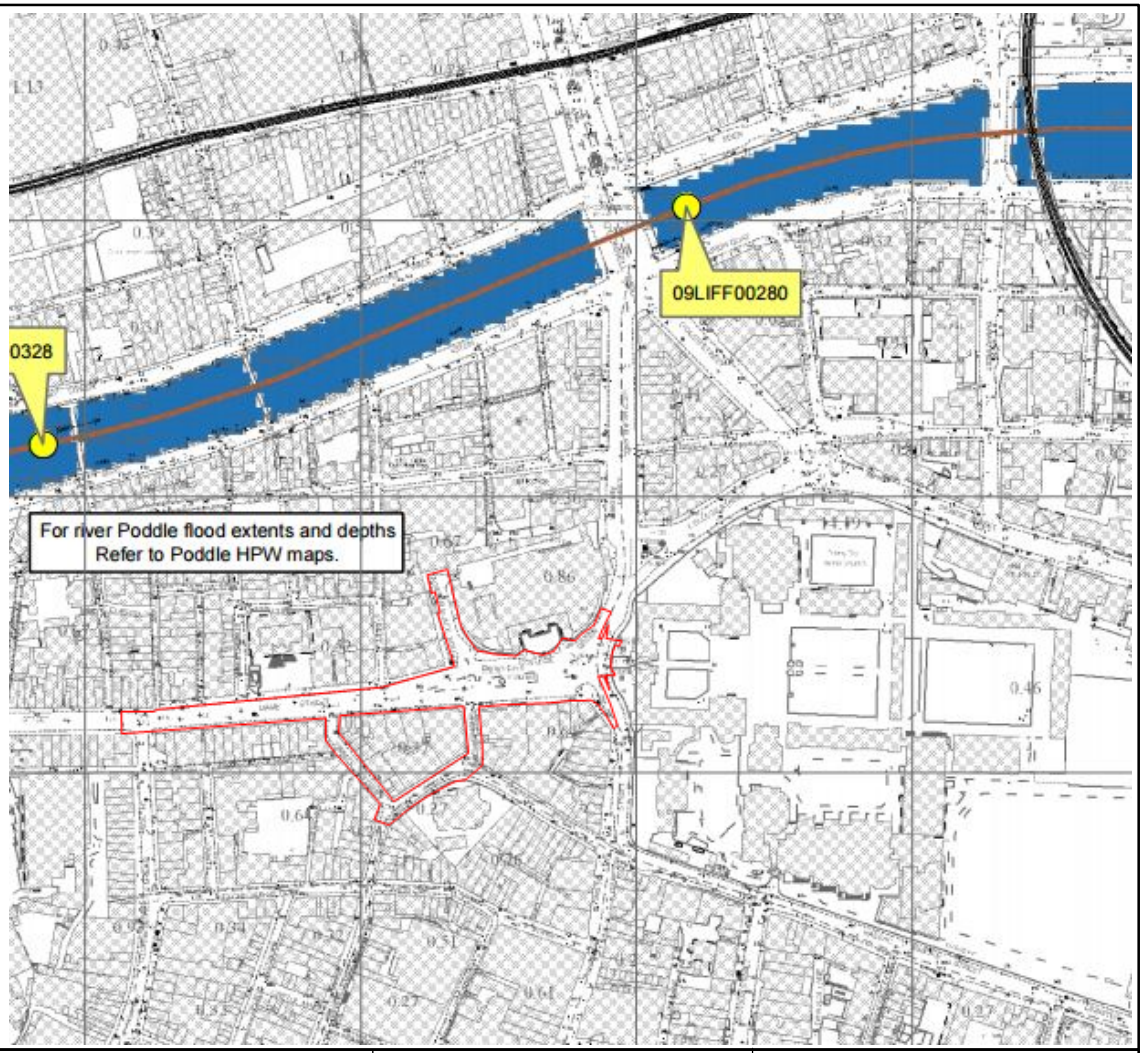

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Legend

- 10% Fluvial AEP Event
- 1% Fluvial AEP Event
- 0.1% Fluvial AEP Event
- Modelled River Centreline
- AFA Extents
- Wall
- Defended Area
- 1% AEP — Standard of Protection of Flood Defence (Walls)
- Node Point
- Node ID — Node Label
- Extent of main works

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

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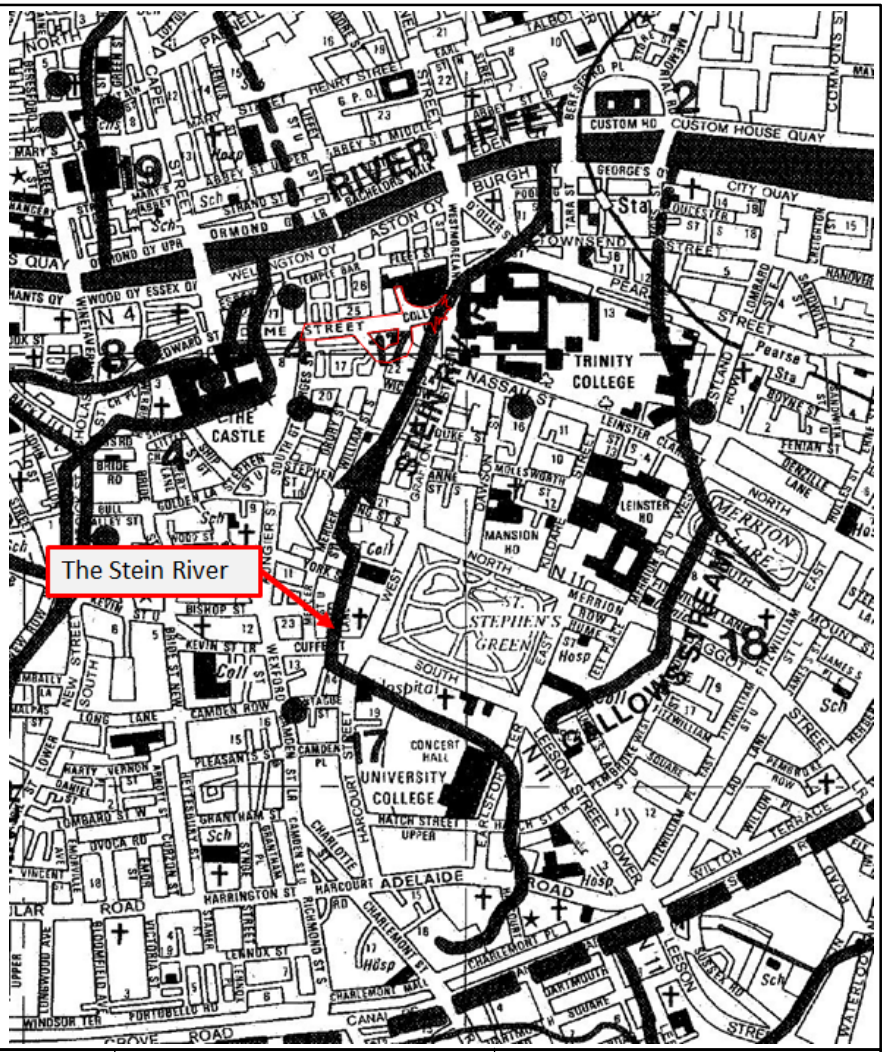
Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
12.10	**P0**

A4



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Extent of main works

Issue	Date	By	Chkd	Appd
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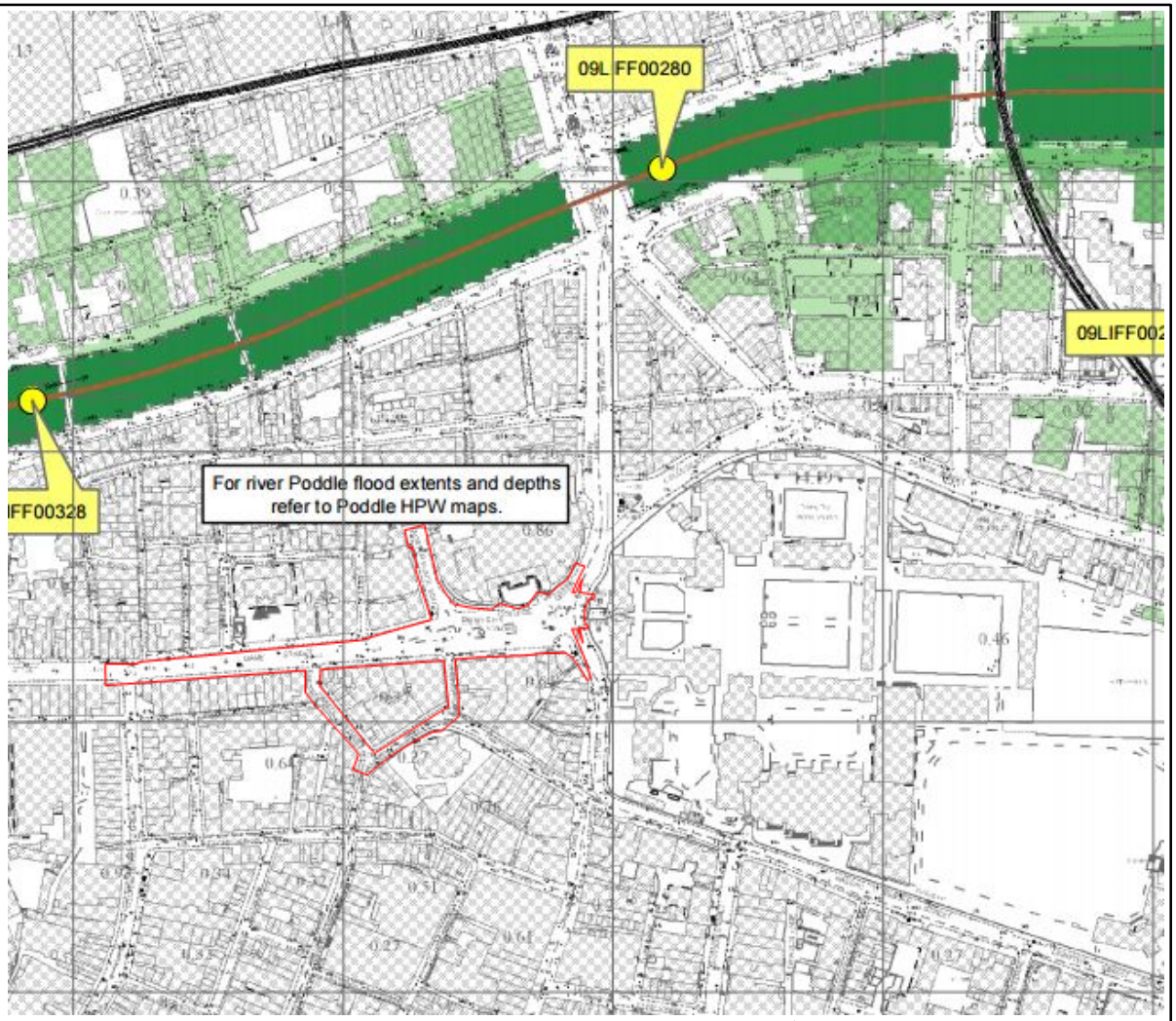
River Stein

Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
12.11	**P0**

A4



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Legend

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- 0.5% Tidal AEP Event
- 0.1% Tidal AEP Event
- Modelled River Centreline
- AFA Extents
- Embankment
- Wall
- Defended Area
- 1% AEP — Standard of Protection of Flood Defence
- 1% AEP — (Walls / Embankments)
- Node Point
- Node ID — Node Label
- Extent of main works

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

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Job No
252740

Drawing Status
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Drawing No
12.12

Issue
P0

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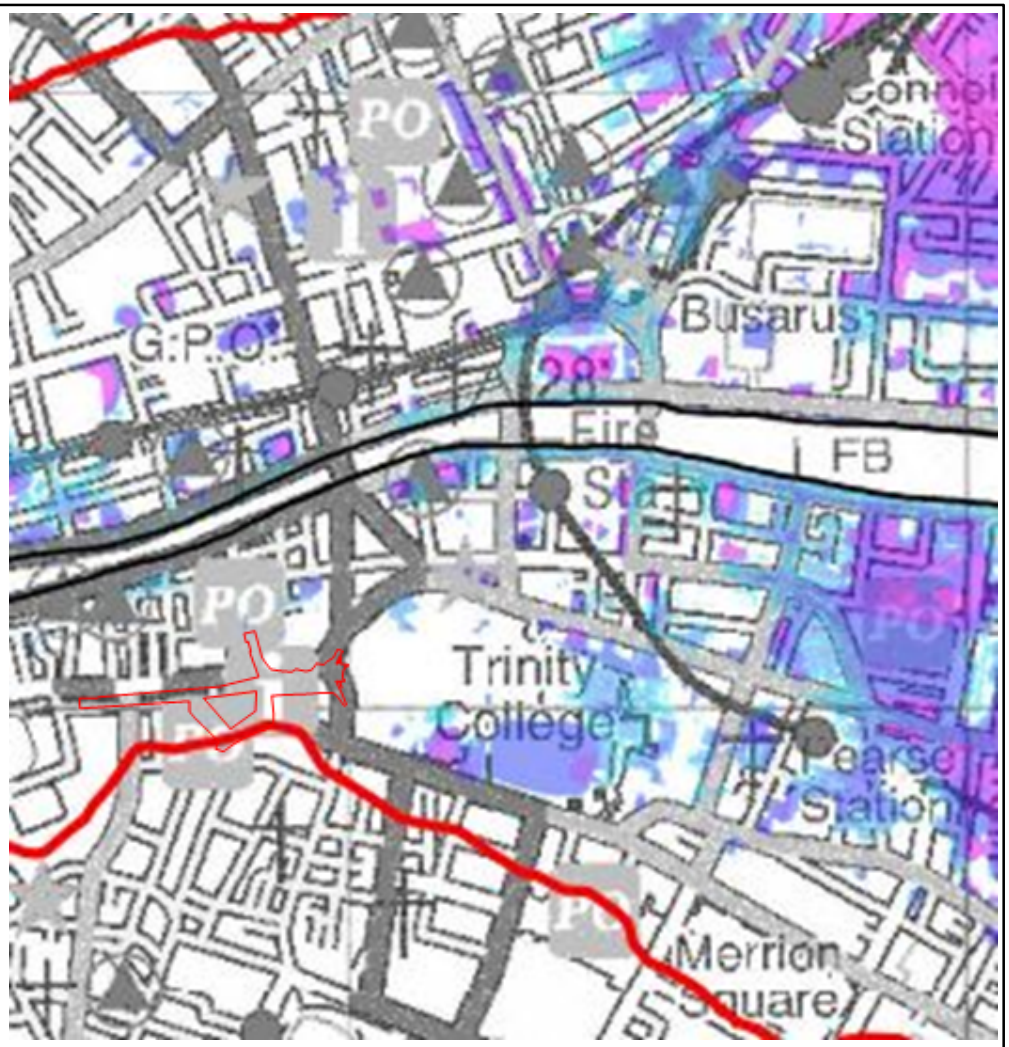

20/01/2017 14:40:53

Legend:

Depth Grid

- 0 -0.25 m
- 0.25 - 0.50 m
- 0.50 - 1 m
- 1.00 - 1.50 m
- 1.50 - 2.00 m
- > 2.00 m

- Extent of main works
- Inland DTM Extent
- High Water Mark (HWM)
- Node Point
- Point 34 Node Label (refer to table)

Issue	Date	By	Chkd	Appd
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Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
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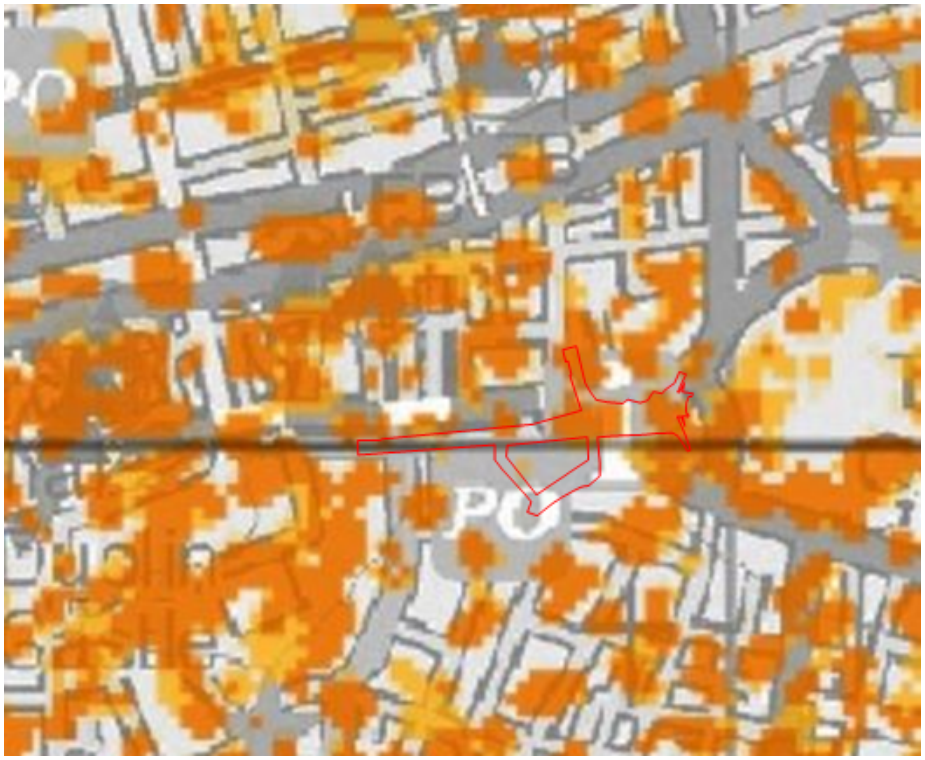

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LEGEND

- 10% AEP Pluvial
- 1% AEP Pluvial
- 0.5% AEP Pluvial
- Extent of main works

Issue	Date	By	Chkd	Appd
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Pluvial Flood Extent

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252740	**Preliminary**

Drawing No	Issue
12.14	**P0**

A4

LEGEND

- 10% AEP Pluvial
- 1% AEP Pluvial
- 0.5% AEP Pluvial
- Extent of main works

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

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PFRA Pluvial Flood Extent

Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
12.15	**P0**

20/01/2017 14:40:53

A4

N

Vulnerability class	Land uses and types of development which include*:
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

*Uses not listed here should be considered on their own merits

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Vulnerability Classification

Job No
252740

Drawing Status
Preliminary

Drawing No
12.16

Issue
P0

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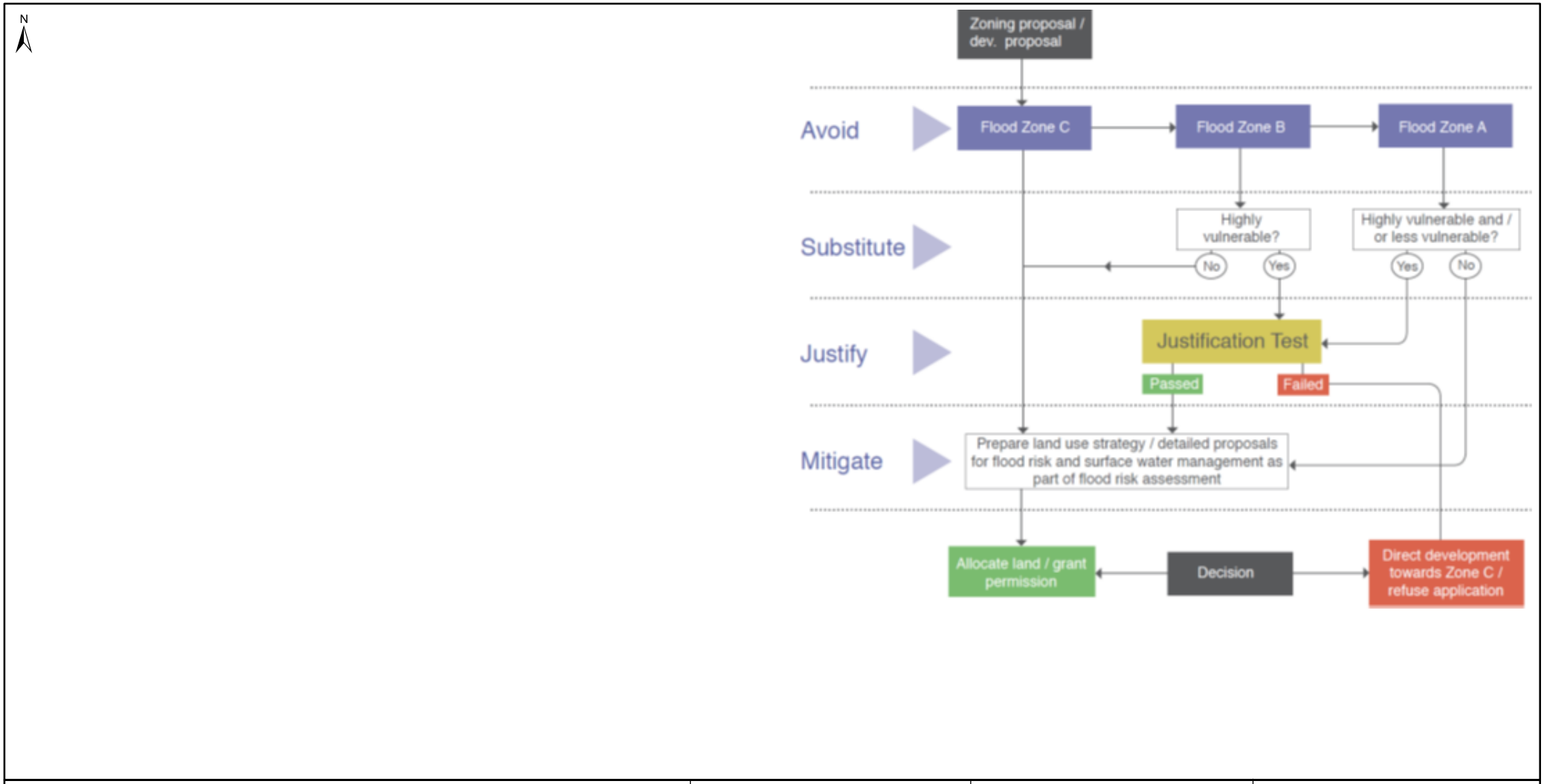
A4



20/01/2017 14:40:53

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

ARUP

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Client

Dublin City Council

Job Title

College Green Traffic Management Measures and Civic Plaza

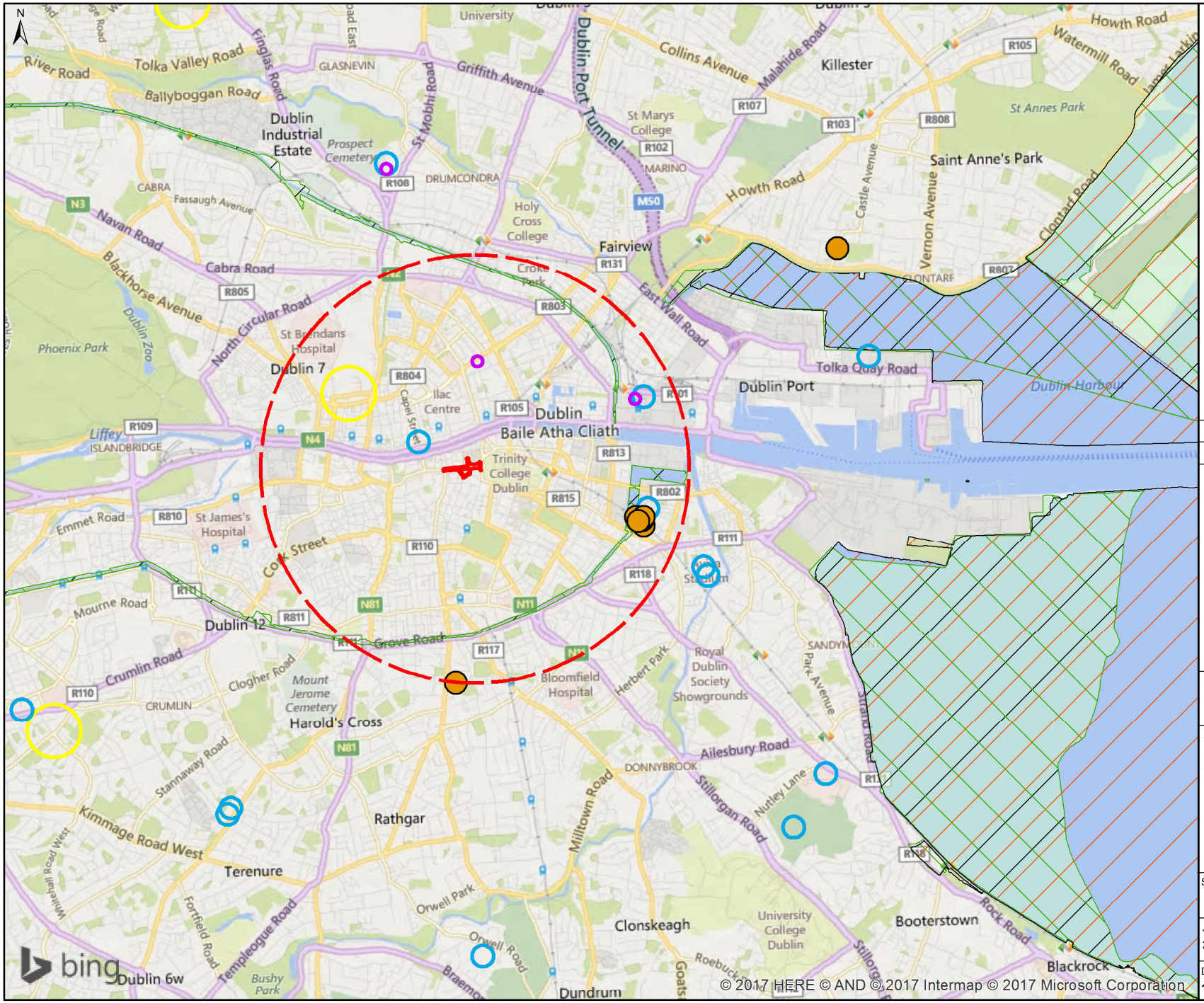
Sequential approach mechanism in the planning process

Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
12.17	**P0**

MXD Location C:\Users\jenny.flink\Desktop\A4_Template_Landscape_Vertical_Dublin.mxd

A4



03/05/2017 09:58:13

Legend

- Extent of main works
- 2km radius
- Wells (10m location accuracy)
- Wells (100m location accuracy)
- Wells (1km location accuracy)
- Wells (200m location accuracy)
- Wells (500m location accuracy)
- Special Protected Area (SPA)
- Proposed National Heritage Area (pNHA)
- Special Area of Conservation (SAC)

Issue	Date	By	Chkd	Appd
P0	2017-01-23	JF	AO	CN

Kilometers

0 0.5 1 2

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Job Title
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Sensitive features in the vicinity of the study area

Scale at A4
1:50,000

Job No	Drawing Status
252740-00	**For information**

Drawing No	Issue
12.18	**P0**

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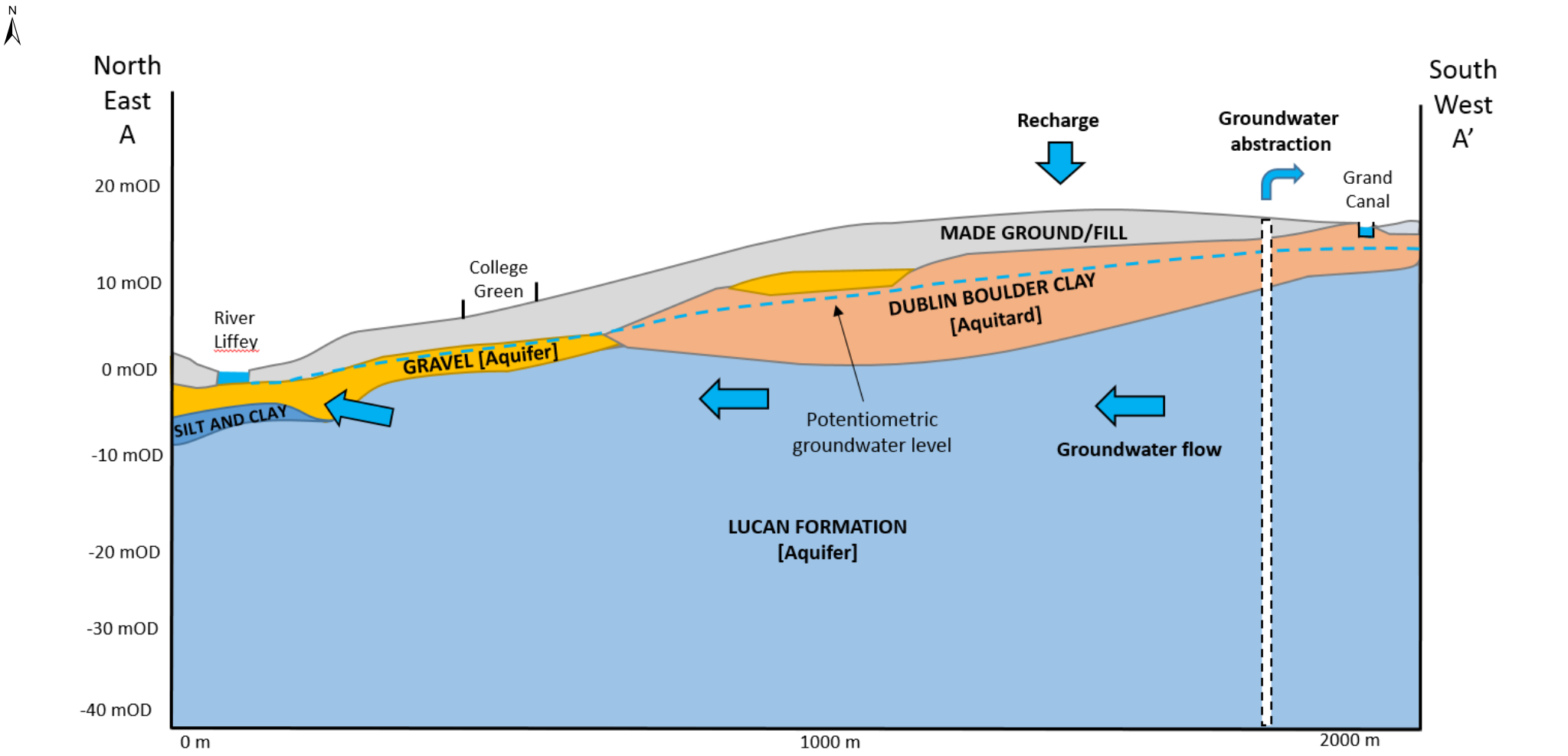
A4



20/01/2017 14:40:53

Issue	Date	By	Chkd	Appd
P0	2017-01-20	JF	AO	CN

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Job Title
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Job No	Drawing Status
252740	**Preliminary**

Drawing No	Issue
12.19	**P0**

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