



## Eastern CFRAM Study

## Poddle Options Report

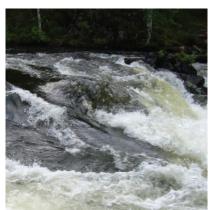
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#### NOTE:

The analysis presented in this report is based on the baseline results of the hydraulic modelling that had been conducted by October 2013. Subsequently, a further technical review was carried out, which resulted in modifications being made to the model such as, for example, the inclusion of Poddle Park Wall as a hydraulically significant structure. These modifications resulted in changes in the flood extents that are not represented in this document. However, RPS are confident that these hydraulic refinements will not reduce the damage values detailed in this report such that the preferred option becomes economically unviable, nor change the preferential order of the options.

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APPENDIX E Assessment of Poddle Diversion on River Dodder

#### **ABBREVIATIONS**

AEP Annual Exceedance Probability
AFA Area for Further Assessment

BCR Benefit Cost Ratio

CFRAM Catchment Flood Risk Assessment and Management

CPI Consumer Price Index

DEHLG Department of Environment, Community and Local Government (previously known as

the Department of Environment, Heritage and Local Government)

FCERM Flood or Coastal Erosion Risk Management

FFL Finished Floor Level

FHRC Flood Hazard and Research Centre

FRA Flood Risk Assessment
FRM Flood Risk Management

FRMP Flood Risk Management Plan

HA Hydrometric Area

HEFS High end future scenario
HPW High Priority Watercourse
IRR Individual Risk Receptor
MCM Multi Coloured Manual
MRFS Mid range future scenario
OPW Office of Public Works

PFRA Preliminary Flood Risk Assessment

pvD present value Damage RBD River Basin District

RMP Record of Monuments and Places
SAC Special Area of Conservation

SMR Sites and Monuments Record

SI Statutory Instrument
SoP Standard of Protection
SPA Special Protection Area

SSA Spatial Scale of Assessment

UoM Unit of Management

#### 1 INTRODUCTION

The Office of Public Works (OPW) commissioned RPS to undertake the Eastern Catchment-based Flood Risk Assessment and Management Study (Eastern CFRAM Study) in June 2011. The Eastern CFRAM Study was the second River Basin District (RBD) level CFRAM study to be commissioned in Ireland under the EC Directive on the Assessment and Management of Flood Risks 2007, the EU Floods Directive, (Reference 1) as implemented in Ireland by SI 122 of 2010 European Communities (Assessment and Management of Flood Risks) Regulations 2010 (Reference 2). The Eastern CFRAM Study will culminate in 2016 with the development of Flood Risk Management Plans (FRMPs) which will include Flood Risk Management Measures designed to deal with identified flood risk.

The Poddle catchment is located within the Eastern CFRAM study area (Figure 1.1). Due to the very significant recent flooding and risk to life in the Poddle catchment, it was prioritised within the Eastern CFRAM Study programme and an advance project has been carried out during 2013. The purpose of this advance project was to accelerate the identification of Preferred Flood Risk Management Options for the catchment to be taken forward to implementation by the Local Authorities within which the catchment is located (i.e. Dublin City Council and South Dublin County Council).

The Poddle Options report details the generic methodology for the flood risk assessment and development of flood risk management options to be carried out for all areas being studied in the Eastern CFRAM Study will providing the specific findings for the River Poddle area being studied. While it is usual to prepare a preliminary options report to be used for the consultation stage of the process this report, due to its accelerated nature, includes the consultation and presents the final Flood Risk Management Options to be taken forward to detailed design. The preferred Flood Risk Management Options identified in this report are recommended to be developed and progressed by a more detailed subsequent study.

#### 1.1 GENERAL INFORMATION ON THE EASTERN CFRAM STUDY

As shown in figure 1.1 The Eastern CFRAM Study Area covers approximately 6,250 km² and includes four Units of Management; Hydrometric Area (HA) 07 (Boyne), HA08 (Nanny – Delvin), HA09 (Liffey-Dublin Bay) and HA10 (Avoca-Vartry). There is historical evidence of a high level of flood risk within certain areas of the Eastern CFRAM Study area with significant coastal and fluvial flooding events having occurred in the past. A detailed account of historical flooding can be found in the Eastern CFRAM Study inceptions reports in which can be downloaded from the Eastern CFRAM Study website at www.eastcframstudy.ie.

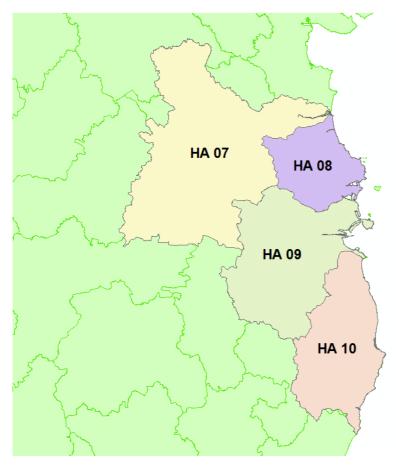


Figure 1.1 - Eastern CFRAM Study Area

The objectives of the Eastern CFRAM Study are to:

- Identify and map the existing and potential future flood hazard within the Study Area.
- Assess and map the existing and potential future flood risk within the Study Area.
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area.
- Prepare a set of Flood Risk Management Plans (FRMPs) for the Study Area, and associated Strategic Environmental and, as necessary, Habitats Directive (Appropriate) Assessment, that set out the policies, strategies, measures and actions that should be pursued by the relevant bodies, including OPW, Local Authorities and other stakeholders, to achieve the most cost effective and sustainable management of existing and potential future flood risk within the Study Area, taking account of environmental plans, objectives and legislative requirements and other statutory plans and requirements.

#### 1.2 EASTERN CFRAM STUDY ACTIVITIES

To achieve the study objectives the Eastern CFRAM Study has carried out a range of activities. Each activity, while focusing on a specific task, is connected to and informs the other activities. Figure 1.2 summarises the activities involved in the study and how they relate to each other.

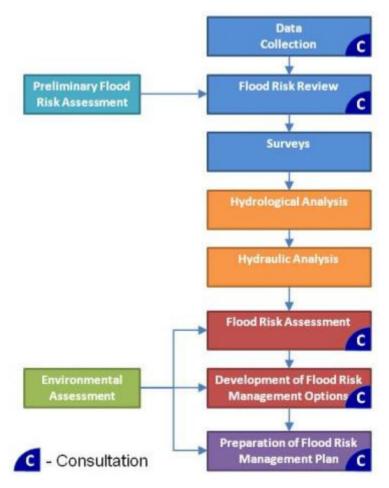


Figure 1.2 - Eastern CFRAM Study activities

The main outputs and reports associated with the study activities are listed in the table below. An explanation of each activity's output(s) are summarised in sections 1.1.1 to 1.1.11.

Table 1.1 - Outputs of study activities

| Activity                                     | Output  |
|--|---|
| Preliminary Flood Risk Assessment            | <ul> <li>National fluvial flood maps</li> <li>Identification of Areas for Further<br/>Assessment</li> </ul>     |
| Data Collection                              | • -   |
| Flood Risk Review                            | Confirmation of Areas for Further     Assessment  |
| Surveys                                      | <ul> <li>Survey data for all watercourses identified<br/>for assessment</li> </ul>                              |
| Hydrological Analysis                        | <ul> <li>Estimation of flows for all watercourses for<br/>all flood events</li> <li>Hydrology report</li> </ul> |
| Hydraulic Analysis                           | <ul><li>Flood hazard maps</li><li>Hydraulics report</li></ul>   |
| Flood Risk Assessment                        | <ul><li>Flood risk maps</li><li>Preliminary options report</li></ul>  |
| Development of Flood Risk Management Options | <ul> <li>Identification of flood risk management measures and options</li> </ul>                                |

| Activity   | Output  |
|--|---|
|  | Preliminary options report  |
| Environmental Assessment (including Strategic Environmental Assessment (SEA) and Appropriate Assessent (AA)) | <ul> <li>SEA Screening Statement, SEA Scoping<br/>Report, SEA Environmental Report, SEA<br/>Statement</li> <li>AA Screening Statement, Natura Impact<br/>Statement</li> </ul> |
| Communications Activities  | <ul> <li>Influence on draft maps, options and FRMPs</li> <li>Communications synthesis reports</li> </ul>  |
| Preparation of Flood Risk Management Plan  | Flood Risk Management Plan  |

#### 1.2.1 Preliminary Flood Risk Assessment

In 2011 the OPW completed a Preliminary Flood Risk Assessment (PFRA) in accordance with the EU Floods Directive. The objective of the PFRA is to identify areas where the risks associated with flooding might be significant. The PFRA provides maps showing areas deemed to be at risk. The PFRA identified Areas for Further Assessment (AFAs) which were then taken forward in the CFRAM programme. The documentation associated with the PFRA including the flood maps can be accessed through the national CFRAM website www.CFRAM.ie/pfra.

#### 1.2.2 Data collection

An initial data collection was carried out to capture the relevant information to meet the objectives of the project. This main proportion of this activity was carried out at the start of the project but is also ongoing as new information is made available and new data requirements identified. Details of the initial data collection process can be found in the Eastern CFRAM Study inception reports which can be accessed through the Eastern CFRAM Study website www.eastcframstudy.ie.

#### 1.2.3 Flood Risk Review

The Flood Risk Review (FRR) was completed in September 2011 for the Eastern CFRAM Study. RPS was required to review the output of the preliminary flood risk assessment and all other information and knowledge readily available during the initial stages of the Eastern CFRAM Study. The data was assessed and identified AFAs where potential significant flood risk exists or might be considered likely to exist including areas other than those identified through the PFRA. Areas where significant flood risk does not exist and no further assessment required were also identified as part of the FRR. The findings of the FRR can be found in the Flood Risk Review Report and maps which can be accessed through the Eastern CFRAM Study website www.eastcframstudy.ie.

#### 1.2.4 Surveys

Before progressing to the hydrological and hydraulic analysis activities the topographical data for each watercourse and associated floodplains identified for assessment was required. This activity started in 2011 and was completed in October 2012. The outputs of the survey were LiDAR information of floodplains, river channel cross sections and geometrical data for structures located in the river channel or influencing the hydraulic nature of the river.

#### 1.2.5 Hydrological Analysis

The hydrological analysis encompasses all aspects of flood hydrology including review of historic flood events within the AFAs, flood frequency analysis and design flow estimation. The review of historic flood events and initial flood frequency analysis ( to determine the statistical frequency / severity of historic flood events within the AFAs) was completed for the Eastern study area in August 2012 and is contained within the Inception Reports. The second stage of the hydrological analysis focuses on design flow estimation such that design flows for various risk scenarios can be defined and used as inputs for hydraulic modelling. The approach to design flow estimation relies heavily on defining the index flood, equivalent to the statistical median from a series of annual peak flood flows (equivalent to a 50% chance of occurring in any given year). The design flow estimation includes a more detailed flood frequency analysis to define appropriate flood growth behaviour for each catchment / subcatchment in order to define design events based on scaling of the index flood flow. The hydrological analysis also includes consideration of the factors which will affect future changes in flows such as

catchment changes and climate change. The hydrological analysis stage overlaps with the hydraulic analysis as design flow estimates are tested and refined through the models against observed data. Details of the hydrological analysis can be found in Eastern CFRAM Study HA09 Hydrology Report.

#### 1.2.6 Hydraulic Analysis

Dynamic hydraulic models have been developed for all the areas of assessment. These models simulated how each watercourse will react to various sizes of floods and its interaction with the surrounding floodplain. The output of this analysis is a Hydraulics Report in addition to a series of flood extent, zone, depth, velocity and risk-to-life maps known collectively as flood hazard maps which are generated based on the model results. Details of the hydraulic analysis can be found in the Eastern CFRAM Study HA09 Hydraulics Report.

#### 1.2.7 Flood Risk Assessment

The Flood Risk Assessment (FRA) is detailed in this report and its main output is to achieve one of the CFRAM study objectives; assess and map the existing and potential future flood risk within the Study Area. The FRA focuses on the receptors at risk from flooding and are categorised as either social (including risk to people), environmental, cultural heritage or economic receptors.

#### 1.2.8 Development of Flood Risk Management Options

The development of Flood Risk Management Options is detailed in this report and its main output is to achieve one of the CFRAM study objectives; identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area. The output of this activity is to present FRM options for the receptors identified during the FRA. This is achieved through a screening process and analysis of the options in order to identify which are the most appropriate.

#### 1.2.9 Environmental Assessment

Strategic Environmental Assessment (SEA) is a process to evaluate, at the earliest appropriate stage, the environmental effects of a plan or programme before it is adopted. It also gives the public and other interested parties an opportunity to comment and to be kept informed of decisions and how they were made. The outputs of the process include an SEA Screening Statement notifying the decision to carry out SEA, an SEA Scoping Report outlining the environmental issues considered by the SEA, an SEA Environmental Report outlining the assessment of the potential effects of the measures in the Flood Risk Management Plans on aspects of the environment, and an SEA Statement detailing how the SEA process influenced the development of the Flood Risk Management Plans.

It has been concluded that, given the nature of the options proposed, the Poddle work is more appropriately considered a 'project' under the definition of the EIA Directive than a 'plan' or 'programme' under the SEA Directive. Therefore, the SEA process does not apply to the Poddle works. It is however strongly recommended that the Part VIII route is followed and that an Environmental Impact Report is completed to support the Part VIII planning application. This should include an assessment of the potential impacts of the project on flora and fauna, cultural heritage and landscape as a minimum and should be carried out by suitable qualified specialists. The report should also contextualize the works within the Eastern CFRAM Study and where possible use similar and compatible assessment criteria to ensure there is no potential for conflict with the Eastern CFRAM Study process. The Eastern CFRAM Study will address these advanced works in the context of baseline conditions which will reflect the flood relief works for this catchment. In this way the cumulative impacts associated with the wider CFRAM Study will be captured more appropriately at the CFRAM Study level of assessment.

Appropriate Assessment (AA) is a process which ascertains if there are internationally important sites whose integrity could be significantly adversely affected by the implementation of a plan or project. Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) together form the Natura 2000 network of protected areas. Outputs of the process include an AA Screening Statement notifying the decision to carry out AA and a Natura Impact Statment outlining the assessment of the potential effects on Natura 2000 sites of the measures contained in the Flood Risk Management Plans.

AA screening has been undertaken in relation to the Poddle preferred options. It was concluded that the implementation of any of the preferred options within the Poddle catchment would not have the potential to result in adverse impacts to the Natura 2000 network, either alone or in combination with other plans or projects. Therefore, the process did not proceed to Stage 2, Appropriate Assessment.

#### 1.2.10 Communications Activities

Communications activities include elected member briefings, public consultation days, stakeholder workshops, website consultations and consultation with progress group members and other key stakeholders. Stakeholder input influences the technical review of flood maps, flood risk management options and Flood Risk Management Plans.

#### 1.2.11 Preparation of Flood Risk Management Plan

This is the last activity of the Eastern CFRAM Study and will follow the Preliminary Options Report. The report will detail the work carried out during the entire study including the outcomes of the PFRA, flood hazard assessment, flood risk assessment, FRM objectives, environmental considerations, FRM options, programme or work and plan monitoring and review.

#### 1.3 PURPOSE OF THE OPTIONS REPORT

The main objectives of the preliminary options report are to detail the activities associated with Flood Risk Assessment and the development of Flood Risk Management Options and to present the outcomes of each.

The report first details the flood risk to the area being studied based on the following four groups of receptors:

- Society (including risk to people);
- The Environment:
- Cultural Heritage;
- The Economy.

This assessment informs how best to manage the present and future flood risk to the area being studied.

The second part of this report details the decision making process in identifying the most appropriate FRM options and details of the options to be taken forward to consultation.

#### 1.4 INTRODUCTION TO THE OPTIONEERING PROCESS

As discussed in section 1.1, optioneering is a process where the flood risk to an area is identified and quantified which informs what the most appropriate FRM options are. This is carried out through a series of activities summarised in figure 1.3.

The activities shown in the blue boxes aim to identify and assess the flood risk. The starting point in this process is to identify the spatial scale of assessment (SSA). The following SSAs are defined:

- Unit of Management SSA refers to a hydrometric area. There are four Units of Management within the Eastern CFRAM study area;
- Sub-Catchment SSA refers to the catchment of the principle river on which an AFA sits;
- AFA SSA refers to the individual AFA being considered only;
- IRR SSA refers to Individual Risk receptor.

Identifying the SSA informs the FRM method screening process by assuring that only methods appropriate to the spatial scale are considered.

The next step in the optioneering process is the review of the flood hazard maps. The output of the hydraulic modelling is the flood hazard maps. The flood hazard maps are then used to assess the flood risk and produce flood risk maps. The flood risk receptors as defined in section 1.1 are assessed in order to ascertain where flood risk management will be required and to what extent. These activities are detailed in chapter 4 of this report.

On quantifying the flood risk the FRM methods are screened to rule out unacceptable methods. The remaining methods are then developed further and combined to make potential FRM options. This process is described further in chapter 7 and illistrated in the orange boxes.

The FRM options are assessed against a set of criteria and objectives and scored in order to identify the preferred options (maroon box). These options are then presented for consultation with the OPW, progress group and steering group (consisting of local authorities and key stakeholders) and the preferred options indentified are taken forward to public consultation, thereby allowing the public the opportunity to influence the options (purple box). Comments from the public consultation are then considered and if appropriate used in updating preferred options which in turn becomes the FRM Measure to be presented in the draft Flood Risk Management Plan (FRMP). Environmental assessment (SEA and AA) feeds into the screening of the FRM methods, the development of potential FRM options, the Multi Criteria Analysis (see section 7.3) and consultation activities (green box).

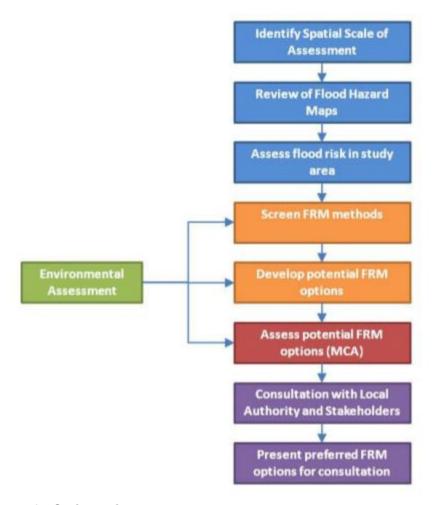


Figure 1.3 - Optioneering process

#### 2 DATA COLLECTION

This section details the data used in the optioneering process. The data was received primarily from the OPW or produced by RPS through the hydraulic analysis within Eastern CFRAM Study activities. Supplementary data was also received from Local Authorities and stakeholders. The data was received in various formats including GIS, AutoCAD, MS Excel and MS Word. The following sections list the data used for the various activities in the optioneering process.

#### 2.1 BACKGROUND MAPPING

Mapping was used throughout to aid the various tasks. This included assessing the flood risk in the area being studied and identifying the receptors at risk. The maps were used to locate and inform the alignment of proposed FRM options and to reference the options being displayed in the various maps produced. The table below summarises the maps that were used.

Table 2.1 - Background Mapping data

| Data                           | Use  |
|--------------------------------|--|
| OSi 210,000 scale raster map   | Various tasks  |
| OSi 50,000 scale raster map    | Various tasks  |
| OSi 10,000 scale Digi-City map | Various tasks  |
| OSi 6 inch scale map           | Historical review  |
| OSi Ortho Photography          | Various tasks  |
| OSi 5,000, scale vector map    | Various tasks  |
| OSi 2,500, scale vector map    | Various tasks  |
| OSi 1,000, scale vector map    | Various tasks  |
| Google maps                    | Identification of receptors and location of FRM measures |
| Bing maps                      | Identification of receptors and location of FRM measures |

#### 2.2 RECEPTORS

The following data was used to identify and assess the social, environmental, cultural heritage and economic receptors at flood risk within the area being studied.

Table 2.2 - Receptor data

| Data   | Use   |
|--|---|
| Primary Schools, Post Primary Schools, Third Level | Flood Risk Assessment                       |
| Fire Stations                                      | Flood Risk Assessment                       |
| Garda Stations                                     | Flood Risk Assessment                       |
| Civil Defence                                      | Flood Risk Assessment                       |
| OPW buildings                                      | Flood Risk Assessment                       |
| Nursing Homes, Hospitals, Health Centres           | Flood Risk Assessment                       |
| Geo-Directory (Oct 2010)                           | Flood Risk Assessment and Damage Assessment |
| Utility Infrastructure Assets                      | Flood Risk Assessment                       |
| Road   | Flood Risk Assessment                       |
| Rail   | Flood Risk Assessment                       |

| Data                             | Use                       |
|----------------------------------|---------------------------|
| Ports                            | Flood Risk Assessment     |
| Airports                         | Flood Risk Assessment     |
| Architectural Heritage           | Flood Risk Assessment     |
| National Monuments               | Flood Risk Assessment     |
| National Heritage Area           | Flood Risk Assessment     |
| Proposed National Heritage Area  | Flood Risk Assessment     |
| Special Area of Conservation     | Flood Risk Assessment     |
| Special Protected Area           | Flood Risk Assessment     |
| Pollution Sources                | Flood Risk Assessment     |
| Development and Local Area Plans | Assessment of FRM methods |
| Historical Flood Data            | Flood Risk Assessment     |
| OPW Channels                     | Assessment of FRM methods |
| OPW Embankments                  | Assessment of FRM methods |
| OPW Benefiting Land              | Assessment of FRM methods |
| River Centrelines                | Various tasks             |
| Lakes                            | Various tasks             |

#### 2.3 FLOOD HAZARD

The output of the hydraulic analysis provides details on the flood extent, depth, velocity, risk to life and flood zones. This was used to inform the flood risk assessment, the screening of FRM methods, developing and assessing potential FRM options. The following datasets were used.

Table 2.3 - Flood Hazard data

| Data  | Use   |
|---|---|
| Poddle flood extent raster (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events) | Establish flood extent and depth for Flood Risk Assessment and developing FRM options |
| Poddle HEFS (10%, 1%, 0.1% AEP flood events)  | Developing FRM options  |
| Poddle MRFS (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events)                | Developing FRM options  |

#### 2.4 SURVEY DATA

Surveys were carried out by Murphy Surveys for the Eastern CFRAM Study. This consisted of surveying river cross sections, and specified structures such as culverts, bridges and weirs. Existing defences were surveyed and their geometric data recorded along with condition assessment being carried out. LiDAR surveys were flown for all relevant areas within the area being studied providing detail of the topography of the flood plain.

Table 2.4 - Survey data

| Data                           | Use  |
|--------------------------------|--|
| Channel and Structure survey   | Flood Risk Assessment and developing FRM options |
| Defence asset condition survey | Flood Risk Assessment and developing FRM options |

| Data              | Use                   |
|-------------------|-----------------------|
| Property survey   | Flood Risk Assessment |
| Floodplain survey | Various tasks         |

#### 2.5 ECONOMIC ASSESSMENT

The following data was used during the economic assessment. This involved assigning damage to receptors during different flood events and providing costs to FRM options.

Table 2.5 - Economic Assessment data

| Data                       | Use                                       |
|----------------------------|---|
| Cost Database              | Costing FRM options                       |
| Depth Damage Database      | Damage Assessment                         |
| Consumer Price Index data  | Damage Assessment and costing FRM options |
| Market value of house data | Damage assessment                         |
| Purchasing Power Parity    | Damage Assessment and costing FRM options |
| OSi Building polygons      | Damage assessment                         |

#### 3 SPATIAL SCALES OF ASSESSMENT

When considering which FRM methods to assess it is accepted that certain methods will be more appropriate at larger spatial scales and others at smaller spatial scales. It is important therefore to define what spatial scale is being assessed at the beginning of the screening process. This is to avoid a situation where the full impact of a FRM method is missed due to the spatial scale of assessment (SSA) being too small, or the FRM method being considered is ineffective as the SSA is too large. OPW have defined a minimum of four SSAs and these are described in the following sections.

#### 3.1 UNIT OF MANAGEMENT SSA

The Unit of Management SSA refers to a full hydrometric area. For the Eastern CFRAM Study there are four hydrometric areas; Hydrometric Area (HA) 07 (Boyne), HA08 (Nanny – Delvin), HA09 (Liffey-Dublin Bay) and HA10 (Avoca-Vartry).

At this scale, methods that could provide benefits to multiple AFAs within the Unit of Management and other areas should be considered, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

FRM methods and options that might typically be applicable at this scale might include (but are not necessarily limited to):

- · Policy requirements;
- Flood forecasting and warning systems;
- Land Use Management, where applicable;
- Methods implemented under other legislation;
- Requirements for additional monitoring (rain and river level / flow gauges).

#### 3.2 SUB-CATCHMENT SSA

The sub-catchment SSA refers to the catchment of the principal river on which an AFA sits, including areas upstream and areas downstream to the river's discharge into another, larger river or into the sea. This SSA would generally not be applicable to AFAs that are only at risk from coastal flooding, except where multiple AFAs are at risk around an estuarine area, where the estuary area may be treated as a Sub-Catchment SSA.

At this scale, methods that could provide benefits to multiple AFAs within the sub-catchment and other areas should be considered, such as upstream storage or tidal barrages, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

#### 3.3 AFA SSA

The AFA SSA refers to an individual AFA; such areas would include towns, villages, areas where significant development is anticipated and other areas or structures for which the risk that could arise from flooding is understood to be significant. At this scale, methods benefitting only the particular AFA in question are considered, even if the implementation of a given method includes works or activities outside of the AFA, i.e., elsewhere in the sub-catchment or UoM. Examples of where this might apply would be storage options upstream of the AFA, or flood forecasting and warning systems, that provide benefits to no other AFAs than the AFA under consideration, as well as all other FRM methods and options, such as protection methods, conveyance improvement, etc.

There are however instances where considering only single methods to address all risk within the AFA SSA will not be appropriate, and options for many AFAs are likely to comprise a range of methods as necessary to address the risk in different parts of the AFA. Such instances might include:

- Areas along the same watercourse but which could benefit from independent FRM methods and
  where whole AFA methods, which would attempt to provide flood protection to all flood prone
  areas, might not be appropriate or viable. These would be discrete areas of flood risk within an
  AFA (e.g., a large urban area).
- Single or multiple areas along one or more watercourses within the AFA where the cause or mechanism of flooding are physically or effectively hydraulically independent from each other. Examples might include AFAs where:
  - Floods can occur due to different sources (i.e., coastal and fluvial);
  - A steep tributary gives rise to flood risk that causes flooding in an area where the tributary
    is hydraulically independent of flooding that could be caused by the main river running
    through the AFA;
  - Two separate watercourses run through and give rise to separate areas of flood risk in a single AFA and discharge to the sea (or another river).

It is therefore essential that the discrete areas of flood risk within an AFA be identified to inform the screening of FRM methods and avoid duplicate work. It is preferable to incorporate methods into options which will address the flood risk to the entire AFA. however, where this is not viable the preferred option for the AFA may comprise separate methods addressing only individual discrete areas of flood risk, with, where appropriate, recommendations for local / community action and / or the pursuit of minor works to address the flood risk in areas where no viable methods have been identified.

#### 3.4 IRR SSA

The IRR SSA refers to Individual Risk Receptors, such as water treatment works or power stations. This SSA does not need to be considered for significant receptors that are within a broader AFA, as the receptor is then considered as an integral part of that AFA, and analysis of individual receptors within a given AFA is considered to be beyond the scope of the CFRAM studies.

At this scale, methods benefitting only the IRR are to be considered, even if the implementation of a given method includes works or activities outside of the boundary of the IRR i.e., elsewhere in the subcatchment or UoM. All FRM methods and options are potentially applicable at the IRR SSA.

#### 3.5 SPATIAL SCALE OF ASSESSMENT FOR THE RIVER PODDLE

The Poddle River flows through Dublin City. Dublin City has been identified as an AFA. However, due to its size and the complexity of the densely populated and urbanised area, high priority watercourses (HPWs) have been designated within it. The following HPWs are located within the Dublin City AFA.

- Lower Liffey
- River Camac
- River Poddle
- River Santry
- River Carysfort/Maretimo

Each HPW named above is assessed at an AFA scale. The River Poddle has therefore been assessed as an AFA and AFA appropriate FRM methods have been considered. For further details on the FRM methods see chapter 6.

The River Poddle is part of UoM 09 (Liffey-Dublin Bay) and will be assessed within this spatial scale. The next SSA is sub-catchment, however due to the unique circumstances where the whole River Poddle catchment is being assessed at AFA scale the sub-catchment SSA is not relevant or

duplicates the AFA SSA and therefore is not required. The River Poddle is therefore also assessed at AFA scale as discussed. The River Poddle was reviewed for discrete areas of flood risk and it was found that all areas influence all other areas and therefore the smallest SSA being considered is at AFA scale. The following SSAs, as summarised in table 3.1, are therefore to be considered for the River Poddle.

Table 3.1 - Spatial Scales of Assessment for the River Poddle

| SSA           | Name              |
|---------------|-------------------|
| UoM           | Liffey-Dublin Bay |
| Sub-Catchment | Not required      |
| AFA           | River Poddle      |
| IRR           | Not required      |

Due to the River Poddle being prioritised within the Eastern CFRAM Study, FRM methods appropriate at UoM scale have not been assessed. This will be completed in 2016 as part of the deliverables for the Eastern CFRAM Study. The Liffey-Dublin Bay UoM will consider FRM methods which will benefit multiple AFAs and HPWs of which the River Poddle is one. The following AFAs and HPWs are part of the Liffey-Dublin Bay UoM:

- Lower Liffey HPW
- River Camac HPW
- River Poddle HPW
- River Santry HPW
- River Carysfort/Maretimo HPW
- Baldonnel
- Blessington
- Celbridge
- Clane
- Clontarf
- Dublin
- Hazelhatch

- Kilcock
- Leixlip
- Lucan to Chapelizod
- Maynooth
- Naas
- Newbridge
- Raheny
- Sandymount
- Santry
- Sutton & Baldoyle
- Sutton & Howth North
- Turnings/Kileenmore

The extent of the River Poddle being studied is dictated by its catchment and is presented in figure 3.1 below. The upstream extent of the area being studied starts in Tallaght and includes Tymon North, Kimmage, Harold's Cross and Dolphins Barn before finishing at where the River Poddle enters the River Liffey near Dublin Castle.

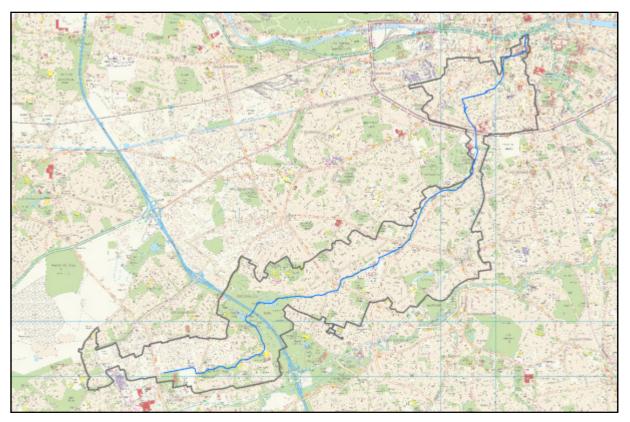


Figure 3.1 - River Poddle Spatial Scale of Assessment

#### 4 FLOOD RISK ASSESSMENT

The aim of the Flood Risk Assessment is to assess and map the potential adverse consequences (risk) associated with flooding in the area being studied to the four receptor groups as described in the table below. The level of flood risk to a receptor can be affected by its location within the flood extent or the proportion of the receptor within the flood extent, the depth to which it floods, the velocity of the water adjacent to the receptor and the receptors' vulnerability to flooding.

Table 4.1 - Flood risk receptor groups

| Flood Risk Receptor Group | Receptor Dataset   | Indicator                                     |  |  |
|---------------------------|--|---|--|--|
| Social                    | Residential Properties   | Location and number of residential properties |  |  |
|                           | Residential Homes (children, disabled, elderly)  | Location, type and number                     |  |  |
|                           | Prisons, Schools (primary, post-<br>primary, third level education),<br>fire stations, garda stations, civil<br>defence, ambulance stations,<br>hospitals, health centres, OPW<br>buildings, government buildings,<br>local authority buildings. | Location, type and number                     |  |  |
|                           | Social amenity sites   |   |  |  |
| Environment               | Special Area of Conservation,<br>Special Protected Area,<br>Groundwater Abstraction for<br>Drinking Water, Pollution<br>Sources, Recreational water<br>including bathing water   | Location, extent and nature                   |  |  |
| Cultural Heritage         | Architectural Heritage, National<br>Monuments, National Heritage<br>Area, Proposed National<br>Heritage Area, Sites and<br>Monument Records, Record of<br>Monuments and Places   | Location, type and number                     |  |  |
| Economic                  | Residential and Commercial Properties  | Location, type, number, depth-damage data     |  |  |
|                           | ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres   | Location, type and number                     |  |  |
|                           | Road networks, Rail networks & Stations, Ports and Harbours  | Location. type. number and length             |  |  |

#### 4.1 FLOOD RISK MAPS

The clearest way to present the flood risk within an area being studied is through flood risk maps. These maps detail the source of the risk and the receptors at risk. The following flood risk maps were produced:

- Social Risk map
- Environmental Risk map
- Cultural Heritage Risk map
- Economic Activity map
- Economic Risk Density map
- Number of Inhabitants map

In areas where there are few receptors it may be possible to combine the social, environmental and cultural heritage receptors together in one map. An example of the social, environmental and cultural heritage risk maps are shown in figure 4.1 below. The economic activity map presents the receptors with a monetary damage according to their type as listed in table 4.1. The economic risk density maps present the annual average damage (AAD) calculated from the damage assessment, for further details on the damage assessment see chapter 5. The AAD is represented by the total damage occurring from all receptors in a square grid. This grid varies from 1km² in urban areas to 5km² in rural area. An example of Economic Risk Density map is shown in figure 4.2. The flood risk maps are presented in appendix A.



Figure 4.1 - Example social, environmental, cultural heritage risk maps



Figure 4.2 - Example economic risk density maps

#### 4.2 FLOOD RISK FROM THE RIVER PODDLE

The following table summarises the flood risk to the area being studied from the River Poddle.

Table 4.2 - Flood risk from the River Poddle

| Flood Risk<br>Receptor<br>Group | Receptor  | Risk  |
|---------------------------------|---|---|
| Social                          | Residential Properties  | 1591 residential properties are a risk from the 0.1% AEP flood event. 837 residential properties are a risk from the 1% AEP flood event. 280 residential properties are a risk from the 10% AEP flood event.  |
|                                 | Residential Homes (children, disabled, elderly)   | None at risk within the 0.1% AEP flood event.   |
|                                 | Prisons, Schools (primary, post-<br>primary, third level education), fire<br>stations, garda stations, civil defence,<br>ambulance stations, hospitals, health<br>centres, OPW buildings, government<br>buildings, local authority buildings. | 2 schools are a risk from the 0.1% AEP flood event.  None at risk within the 1% AEP flood event.  |
|                                 | Social amenity sites  | Multiple parks and open amenity spaces including Tymon Park are at risk from the 10%, 1% and 0.1% AEP flood events, however the risk is deemed to be low as the use of the amenity sites return after the flood event and areas vulnerability to flood damage is low. |
| Environment                     | Special Area of Conservation,<br>Special Protected Area, Groundwater<br>Abstraction for Drinking Water,<br>Pollution Sources, Recreational<br>water including bathing water   | Part of the Grand Canal, a pNHA, is at risk from the 1% and 0.1% AEP event.   |
| Cultural<br>Heritage            | Architectural Heritage, National<br>Monuments, National Heritage Area,<br>Proposed National Heritage Area,<br>Sites and Monument Records,<br>Record of Monuments and Places,<br>UNESCO sites  | The following 11 structures designated by DEHLG as monuments are at risk:  • 3 bridges  • medieval house  • school  • 2 mill  • tannery  • 2 stretches of the River Poddle  • weir  Kimmage Manor, an NIAH site, is at risk from the 1% and 0.1% AEP event.           |
| Economic                        | Residential and Commercial Properties   | The total AAD from residential and commercial properties is €798,481  |
|                                 | ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres  | 1 ESB substation is at risk from the 10%, 1% and 0.1% AEP flood events.   |
|                                 | Road networks, Rail networks & Stations, Ports and Harbours   | The N81 is at risk at Harold's Cross from the 0.1%AEP flood event.  |

#### 5 DAMAGE ASSESSMENT

As part of the economic risk assessment a monetary damage is assigned to certain receptors at risk. This damage represents the costs to the nation if the flood events being considered were to occur. The following receptors are assigned a monetary damage value:

- Residential properties
- Commercial properties
- · National road network and rail network
- Utility infrastructure

The total damage to an area being studied is used to quantify the economic risk and provide the amount of potential benefit that would occur if a FRM measure is put in place which would prevent the damage from occurring.

#### 5.1 DAMAGE ASSESSMENT GUIDELINES

The damage assessment methodology for the CFRAM study follows the guidance in "The Benefits of Flood and Coastal Defence: A Manual of Assessment Techniques" (Flood Hazard Research Centre, Middlesex University, UK, 2005) This document is often referred to as the Multi Coloured Manual (MCM).

The MCM results from research carried out by Middlesex University Flood Hazard Research Centre and provides data and techniques for assessing the benefits of flood risk management in the form of flood alleviation. The MCM has focused on the benefits that arise from protecting residential property, commercial property, and road disruption amongst other areas as experience has shown that these sectors constitute the vast majority of the potential benefits of capital investment.

Based on this research the MCM provides depth damage data for both residential and commercial properties. For certain depths of flood water a damage has been assigned to a property. This damage is a combination of the likely items within the building and the building structure itself. The damage to each property is dependent on the property type, as such the MCM has categorised both the residential and commercial properties. An example of the depth damage data is shown in figure 5.1 below.

|                            |         | ETACHED<br>AND USE O | CODE 11  |            | 2010 PRICE | s         |          | FLOOD DUR | ATION MORE | THAN 12 H | ours     |          |          |          |          |
|----------------------------|---------|----------------------|----------|------------|------------|-----------|----------|-----------|------------|-----------|----------|----------|----------|----------|----------|
|                            |         |                      | [        | DEPTH ABOV | /E UPPER S | URFACE OF | GROUND F | LOOR      |            |           |          |          |          |          |          |
| Components of damage       | -0.3    | 0                    | 0.05     | 0.1        | 0.2        | 0.3       | 0.6      | 0.9       | 1.2        | 1.5       | 1.8      | 2.1      | 2.4      | 2.7      | 3        |
| 1 Paths and paved areas    | 0       | 54.32                | 58.38    | 73 32      | 162 24     | 360.86    | 413.33   | 455.09    | 503.6      | 604.25    | 695.98   | 824.35   | 859.62   | 902.05   | 949.92   |
| 2 Gardens/fences/sheds     | 0       | 04.52                | 102.7    | 202.5      | 705.95     | 1308.73   | 2248.7   | 2948.95   | 3755.38    | 5856.54   | 6811.11  | 8088.28  | 9415.97  | 10109.3  | 10487.34 |
| 3 External main building   | 935.51  | 1223.52              | 1430.1   | 1763.94    | 2321.56    | 2647      | 3129     | 3808.85   | 4520.47    | 5913.69   | 8082.01  | 9828.87  | 12058.9  | 15251.18 | 19279.72 |
| 4 Plasterwork              | 176.84  | 487.74               | 1124.95  | 1712.61    | 2592.26    | 3917.47   | 4739.55  | 5016.94   | 5913.36    | 7178.64   | 8142.19  | 9363.46  | 9918.23  | 10305.43 | 10860.2  |
| 5 Floors                   | 0       | 1756.48              | 6399.48  | 7457.37    | 8453.96    | 9270.39   | 9344.44  | 9418.48   | 9455.5     | 9603.59   | 9751.68  | 9899.77  | 9899.77  | 9899.77  | 9899.77  |
| 6 Joinery                  | 0       | 357.66               | 1572.85  | 4443.87    | 6055.64    | 7510.61   | 7534.94  | 7853.8    | 7951.63    | 8025.14   | 8220.27  | 11396.54 | 11396.54 | 11396.54 | 11396.54 |
| 7 Internal decorations     | 209.19  | 241.8                | 374.99   | 1716.8     | 2753.95    | 2833.64   | 2931.01  | 3104.93   | 3234.52    | 3348.56   | 3462.6   | 3480.28  | 3480.28  | 3480.28  | 3480.28  |
| 8 Plumbing and electrical  | 0       | 0                    | 962.99   | 1726.05    | 2669.08    | 4106.08   | 4395.48  | 4395.48   | 4395.48    | 4395.48   | 4395.48  | 4395.48  | 4395.48  | 4395.48  | 4395.48  |
| Building Fabric Damage     | 1321.54 | 4121.52              | 12026.44 | 19096.46   | 25714.63   | 31954.78  | 34736.44 | 37002.52  | 39729.95   | 44925.9   | 49561.33 | 57277.02 | 61424.8  | 65740.04 | 70749.25 |
| 1 Domestic appliances      | 0       | 0                    | 2.76     | 194.14     | 903.63     | 1657.79   | 1798.06  | 1906.38   | 1907.06    | 1907.74   | 1910.12  | 1911.61  | 1911.61  | 1911.61  | 1911.61  |
| 2 Heating equipment        | 0       | 0                    | 35.91    | 68.21      | 118.1      | 161.3     | 697.84   | 955.69    | 1149.08    | 1149.08   | 1149.08  | 1149.08  | 1149.08  | 1149.08  | 1149.08  |
| 3 Audio/video              | 0       | 0                    | 163.71   | 479.77     | 686.43     | 959.78    | 1287.64  | 1682.48   | 1718.91    | 1718.91   | 1718.91  | 1718.91  | 1718.91  | 1718.91  | 1718.91  |
| 4 Furniture                | 0       | 0                    | 194.6    | 334.79     | 2140.23    | 2175.78   | 2207.94  | 2251.35   | 2335.43    | 2361.77   | 2361.77  | 2361.77  | 2361.77  | 2361.77  | 2361.77  |
| 5 Personal effects         | 0       | 0                    | 57.37    | 143.14     | 281.24     | 430.58    | 642.4    | 785.56    | 859.81     | 974.85    | 1058.12  | 1058.12  | 1058.12  | 1058.12  | 1058.12  |
| 6 Floor coverings/curtains | 0       | 0                    | 1360.09  | 1432.05    | 1432.05    | 1474.94   | 1654.79  | 1667.42   | 1688.06    | 1702.99   | 1702.99  | 1702.99  | 1702.99  | 1702.99  | 1702.99  |
| 7 Garden/DIY/leisure       | 0       | 0                    | 32.38    | 96.52      | 126.4      | 203.42    | 233.81   | 266.64    | 269.59     | 277.21    | 278.09   | 278.09   | 278.09   | 278.09   | 278.09   |
| 8 Domestic clean-up        | 0       | 0                    | 4820.2   | 4820.2     | 5915.8     | 5915.8    | 6884.9   | 6884.9    | 6884.9     | 6884.9    | 8666.9   | 8666.9   | 8666.9   | 8666.9   | 8666.9   |
| Household Inventory Damag  | 0       | 0                    | 6667.02  | 7568.82    | 11603.87   | 12979.4   | 15407.39 | 16400.42  | 16812.85   | 16977.46  | 18845.97 | 18847.46 | 18847.46 | 18847.46 | 18847.46 |
|                            |         |                      |          |            |            |           |          |           |            |           |          |          |          |          |          |
| Total Damage               | 1321.54 | 4121.52              | 18693.46 | 26665.28   | 37318.5    | 44934.18  | 50143.83 | 53402.95  | 56542.8    | 61903.35  | 68407.3  | 76124.49 | 80272.26 | 84587.5  | 89596.71 |
| Total Damage/Square Metre  | 17.07   | 52.5                 | 247.12   | 353.18     | 495.36     | 597.03    | 666.9    | 711.58    | 751.92     | 821.18    | 908.61   | 1013.84  | 1068.33  | 1123.67  | 1188.23  |

Figure 5.1 - MCM's depth damage data for detached houses

#### 5.2 RECORDING DAMAGE ASSESSMENT DATA

The damage assessment is carried out in order to quantify the economic risk to the area being studied. This requires a lot of details to be recorded such as background data, interim calculations and final damage results. As such RPS have created geo-referenced shapefiles, known as economic risk shapefiles, with the relevant data recorded in the their attribute tables, an example is shown in figure 5.2. The damage data for residential properties, commercial properties and utility infrastructure have been grouped into a single point file for each area being studied and polyline file for road

networks. The following sections detail how the damage assessment is carried out and the data that is recorded during various processes within the shapefile attribute tables.

The River Poddle study has produced a shapefile detailing the economic risk to properties called "H09PE\_EcRisk\_Prop".

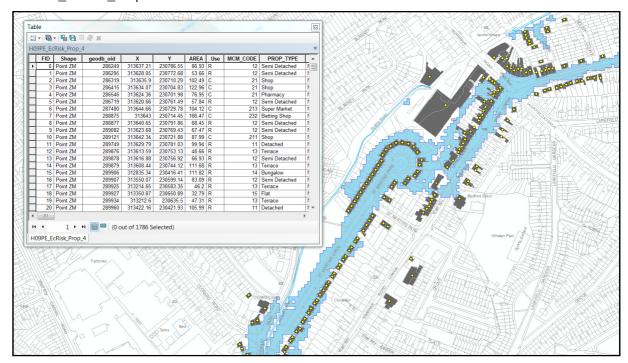


Figure 5.2 - Example shapefile with attribute table showing damage assessment data

#### 5.3 CATEGORISATION OF PROPERTIES

All properties identified as at risk during the flood risk assessment were included in the damage assessment. The first task in this process is to identify the property use. This was carried out according to MCM guidelines, table 5.1 details the various property types. The MCM assigns a code to each property type to aid the damage calculations where a number can more readily be used in calculations rather than a description in text format.

Table 5.1 - MCM property types

| Property Type          | MCM code | Property Type                     | MCM code |
|------------------------|----------|-----------------------------------|----------|
| Detached House         | 11       | Leisure                           | 51       |
| Semi Detached House    | 12       | Hotel                             | 511      |
| Terrace House          | 13       | Boarding House                    | 512      |
| Bungalow               | 14       | Caravan Mobile                    | 513      |
| Flat                   | 15       | Caravan Static                    | 514      |
| Shop/Store             | 21       | Self catering Unit                | 515      |
| (High Street) Shop     | 211      | Hostel (including prisons)        | 516      |
| Superstore/Hypermarket | 213      | Bingo hall                        | 517      |
| Retail Warehouse       | 214      | Theatre/Cinema                    | 518      |
| Showroom               | 215      | Beach Hut                         | 519      |
| Kiosk                  | 216      | Sport                             | 52       |
| Outdoor market         | 217      | Sports Grounds and Playing Fields | 521      |
| Indoor Market          | 218      | Golf Courses                      | 522      |
| Vehicle Services       | 22       | Sports and Leisure centres        | 523      |
| Vehicle Repair Garage  | 221      | Amusement Arcade/Park             | 524      |

| Property Type                | MCM code | Property Type                     | MCM code |
|------------------------------|----------|-----------------------------------|----------|
| Petrol Filling Station       | 222      | Football Ground and Stadia        | 525      |
| Car Showroom                 | 223      | Mooring/Wharf/Marina              | 526      |
| Plant Hire                   | 224      | Swimming Pool                     | 527      |
| Retail Services              | 23       | Public Building                   | 6        |
| Hairdressing Salon           | 231      | School/College/University/Nursery | 610      |
| Betting Shop                 | 232      | Surgery/Health Centre             | 620      |
| Landrette                    | 233      | Residential Home                  | 625      |
| Pub/Social club/wine bar     | 234      | Community Centres/Halls           | 630      |
| Restaurant                   | 235      | Library                           | 640      |
| Café/Food Court              | 236      | Fire/Ambulance station            | 650      |
| Post Office                  | 237      | Police Station                    | 651      |
| Garden Centre                | 238      | Hospital                          | 660      |
| Office                       | 3        | Museum                            | 670      |
| Offices (non specific)       | 310      | Law court                         | 680      |
| Computer Centres (Hi-Tech)   | 311      | Church                            | 690      |
| Bank                         | 320      | Industry                          | 8        |
| Distribution/Logistics       | 4        | Workshop                          | 810      |
| Warehouse (including store)  | 410      | Factory/Works/Mill                | 820      |
| Land Used for Storage        | 420      | Extractive/heavy Industry         | 830      |
| Road Haulage                 | 430      | Sewage treatment works            | 840      |
| Warehouse (electrical goods) | 411      | Laboratory                        | 850      |
| Warehouse (ambient goods)    | 412      | Miscellaneous                     | 9        |
| Warehouse (frozen goods)     | 413      | Car Park                          | 910      |
|                              |          | Public Convenience                | 920      |
|                              |          | Cemetry/Crematorium               | 930      |
|                              |          | Bus Station                       | 940      |
|                              |          | Dock Hereditament                 | 950      |
|                              |          | Electricity Hereditament          | 960      |

For each area being studied all properties found within the 0.1% AEP flood extent were categorised. This was carried out using data gained from site visits, surveys, OSi mapping, An post geo-directory and online mapping. The OSi building polygon layer was used initially to locate all the properties and provide their floor area. Sheds and garages which have no depth damage data in the MCM guidelines were then removed and the remaining building categorised. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.2 - Categorisation of properties data

| Data type                    | Attribute name     | Data details                                     |
|------------------------------|--------------------|--|
| Property ID geodb_oid        |                    | An Post geo-directory database ID                |
| Location                     | "X" and "Y"        | X Y coordinates to Irish National Grid           |
| Floor Area or<br>Road Length | "Area" or "Length" | Floor area of the property or the length of road |
| Property Use                 | Use                | "R" for residential and "C" for commercial       |
| MCM code                     | MCM_CODE           | As per MCM guidelines                            |
| Property type                | PROP_TYPE          | As per MCM guidelines                            |

Within the River Poddle's 0.1% AEP flood extent 1,786 residential and commercial properties (including one utility infrastructure) were categorised.

#### 5.4 PROPERTY THRESHOLD LEVEL

The damage assigned to a property relates to the depth of water above floor level. As such the threshold level of all properties is required as part of the damage assessment. As a general rule of thumb most properties are constructed with the floor level raised 300mm above the adjacent ground level. This was assumed for the Eastern CFRAM Study and is consistent with the assumptions made in the MCM, however it is recognised that this is not always the case as some properties contain basements, while others have a half basement and a raised ground floor. To account for this a survey was carried out using data gained from site visits, surveys, OSi mapping and online mapping. The properties found to have basements were recorded along with properties with a raised ground floor level. For the purposes of this study a conservative approach was assumed and where a basement was found the threshold level was dropped 2.5m below ground level and all raised properties were still assumed to be 300mm above ground level. This accounts for the MCM's methodology of assigning damage which assumes that damage will start at ground level, i.e. -300mm, where the external building structure and plasterwork would be damaged.

To assign a finished floor level (FFL) to properties 300mm was added to the ground level or where a basement was present 2.5m was taken from the ground level. In order to calculate this the ground level at each property is required. For each area being studied a LiDAR survey was carried out capturing the ground level to an accuracy of 0.2m. This survey data was extract at the centre point of each property using the spatial analysis tool within the ARC GIS model package. This was data was attributed to each property as the ground level and the FFL calculated accordingly. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.2 - Property threshold data

| Data type               | Attribute name | Data details  |
|-------------------------|----------------|---|
| Basement present?       | BASEMENT       | "Yes" basement present, "No" no basement  |
| ls ground floor raised  | RAISED         | "Yes" ground floor is raised, "No" ground floor is not raised   |
| Ground level            | GRND_LVL       | LiDAR data extracted at each property, measured in mOD  |
| Finished Floor<br>Level | FFL            | Ground level plus 300mm for properties without basement, ground level minus 2.5m for properties with basement |

Within the River Poddle's 0.1% AEP flood extent 49 properties were identified as having a basement and 40 properties identified as having raised FFLs.

#### 5.5 FLOOD DEPTH OF PROPERTIES

To estimate the damage to a property the depth that it floods to is required. This will vary depending on the size of the flood event. As part of the Eastern CFRAM Study the depths to which the properties flood during the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events were calculated. The depth of flooding is calculated by finding the difference between the flood water elevation and the FFL. To achieve this the maximum flood depth at each property is required. It is recognised that as flood water passes around a structure such as a building the water will be pushed against the upstream face and be forced around the structure. This creates an uneven distribution of water levels around the structure. This was simulated in the hydraulic analysis where buildings were placed in the floodplain forcing the modelled flood to flow around them. To maintain a conservative approach the maximum flood level adjacent to the building was extracted and recorded in the attribute table of the economic risk shapefile. This process was achieved by carrying out a statistical analysis in ARC GIS and was carried out for each property and for each flood event. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.3 - Flood depth of properties data

| Data type                        | Attribute name   | Data details   |
|----------------------------------|--|--|
| Flood level for all flood events | Q1000_ELEV,<br>Q200_ELEV,<br>Q100_ELEV,<br>Q50_ELEV,<br>Q20_ELEV,<br>Q10_ELEV,<br>Q5_ELEV,<br>Q2_ELEV, | The maximum flood level adjacent to the building (mOD) |
| Flood depth for all flood events | Q1000_Dp,<br>Q200_Dp,<br>Q100_Dp,<br>Q50_Dp,<br>Q20_Dp,<br>Q10_Dp,<br>Q5_Dp,<br>Q2_Dp,                 | Difference between the flood level and FFL             |

#### 5.6 FLOOD DAMAGE TO PROPERTIES

Once the depths of flooding are known the damage can be calculated using the MCM depth damage data. This is known as direct damage in that the flooding directly damages assets, it does not account for indirect damages such as heating costs to dry out the house, etc. For each property type a typical damage based on historical data has been assigned to a depth of flooding, an example of which is shown in figure 5.3 below. Depth of flooding and therefore damage is measured relative to the FFL of the property in question and starts at a depth of -0.3m which is the surrounding ground level to the property (please refer to sections 5.4 and 5.5 for more details). These direct damage figures have been updated to 2010 pound sterling prices and are based on the floor area of the building an example of this data is present in figure 5.1. A GIS tool has been developed which provides the direct damage in each flood event for each building in pound sterling 2010 prices per square metre by interpolating between the depth damage figures provided in the MCM guidance. This damage figure is then multiplied by the floor area of the property to give the total damage. This figure is converted to Euro and updated to 2013 prices using the OECD's purchasing power parities (PPP) records and CSO Ireland's consumer price index (CPI). The overall adjustment factor used in the Eastern CFRAM Study was 1.345, the conversion rates are shown below.

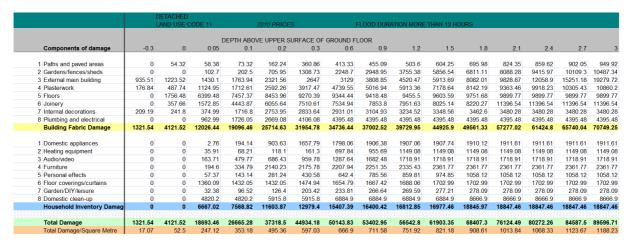


Figure 5.3 - The MCM's depth damage data for a detached house

Table 5.4 - Converting pound sterling to euro using the PPP 2010 values from OECD website

|          | PPP      |  |
|----------|----------|--|
| US - UK  | 0.667    |  |
| US - Ire | 0.853    |  |
| UK - Ire | 1.278861 |  |

Table 5.5 - Conversion rates to current year prices using CPI from CSO Ireland website

|                | CPI      |  |
|----------------|----------|--|
| 2006           | 100      |  |
| 2010<br>Apr-13 | 101.2    |  |
|                | 106.4    |  |
| 2010 - 2013    | 1.051383 |  |

The following details the information and calculations described above were recorded within the economic risk shapefile attribute tables:

Table 5.6 - Flood damage to properties data

| Data type  | Attribute name   | Data details   |
|--|--|--|
| Direct damage<br>per meter square                  | Q1000_M2Dm,<br>Q200_M2Dm,<br>Q100_M2Dm,<br>Q50_M2Dm,<br>Q20_M2Dm,<br>Q10_M2Dm,<br>Q5_M2Dm,<br>Q2_M2Dm        | Damage per meter square to each property according to the depth of flooding from each flood event as per MCM data. Values in pound sterling updated to 2010 costs. |
| Damage to property over full floor area            | 1000_Dm£10, Q200_Dm£10, Q100_Dm£10, Q50_Dm£10, Q20_Dm£10, Q10_Dm£10, Q5_Dm£10, Q5_Dm£10                      | Damage per meter square multiplied by floor area of building.  |
| Damage<br>conversion to<br>euro and 2013<br>prices | 1000_Dm€13,<br>Q200_Dm€13,<br>Q100_Dm€13,<br>Q50_Dm€13,<br>Q20_Dm€13,<br>Q10_Dm€13,<br>Q5_Dm€13,<br>Q2_Dm€13 | Conversion rate (1.345) applied to damage to property over full floor area.  |

#### 5.7 INTANGIBLE DAMAGES AND EMERGENCY COSTS

Apart from the material damages to the building structure and the goods inside the property, it is recognised that there are monetary damages associated with clean up costs, temporary accommodation, stress, etc. To account for this it is OPW policy to assigned intangible damages to all residential properties equal to its direct damages. No intangible damages are assigned to commercial properties as these costs do not apply at the same level with the exception of small family run businesses. To achieve this a survey is carried out identifying these small businesses and an intangible damage equal to the direct damage assigned to the property as well.

Intangible damages are also considered due to road disruption of national roads. Within the area affected by the River Poddle no national road were impacted and therefore no damages considered.

A cost will be associated with emergency services dealing with the flood events. Following the Environment Agency's Flood or Coastal Erosion Risk Management (FCERM) appraisal guidance, which the MCM guidance has been adapted to comply with, a value of 10.7% of the residential damages has been assigned to the emergency services costs. This percentage of the residential damages has been used in this damage assessment also. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.7 - Intangible damages and emergency cost data

| Data type            | Attribute name  | Data details  |
|----------------------|---|---|
| Intangible<br>Damage | Q1000_IntD, Q200_IntD, Q100_IntD, Q50_IntD, Q20_IntD, Q10_IntD, Q5_IntD, Q5_IntD, Q2_IntD,                    | Set equal to the direct damage of residential properties and small family run businesses. |
| Emergency costs      | 1000_emerg,<br>Q200_emerg,<br>Q100_emerg,<br>Q50_emerg,<br>Q20_emerg,<br>Q10_emerg,<br>Q5_emerg,<br>Q2_emerg, | Equal to 10.7% of the residential damages.  |

#### 5.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE

So far in the process damages have been assigned to each property for each flood event. In order to gain an appreciation of the economic risk the overall damage needs to be calculated. This is represented by assessing the likelihood of each of these flood events occurring in any given year and applying this as a percentage to the damage, this is known as the Annual Average Damage (AAD). This can then be taken over the lifetime of the project which has been set at 50 years and discounted back to present day costs, this is known as present value damage (pvD).

Calculating the AAD can best be described by considering the graph shown in figure 5.4. The points shown represent the flood events where the damage has been calculated. Their position on the graph is dictated by the damage caused and the frequency of the flood event occurring in any given year. These points are joined together to create a damage curve. This curve represents all the other flood events that could occur in between the flood events shown, for example the damage that would occur in a 33%AEP event is estimated by the damage curve that is drawn from the 50%AEP event to the 20%AEP event. The area under the curve is therefore a function of the damage and the frequency and gives the AAD. It can be seen then that for many areas being considered the majority of the damage occurs from the smaller yet more frequent flood events rather than the larger flood events that appear at first glance to contribute most to the flood damage. Because the AAD is calculated by the area under the damage curve the more flood events included in the assessment the more accurate the AAD figure will be. However a minimum of three events are required to create a curve but the less events there are the more likely you are to overestimate the AAD. It is also essential to identify the threshold event. This is the event where damage starts to occur. Failure to do this will cut the damage curve short and reduce the area under the graph. The events that were considered for this study were the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events.

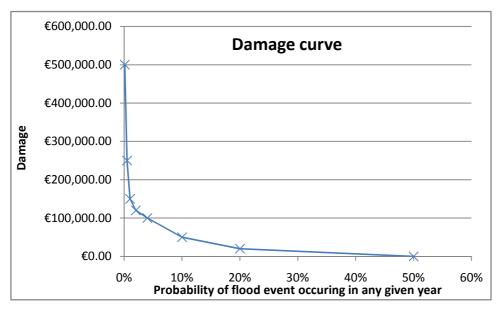


Figure 5.4 - Example damage curve

Once the AAD is calculated the present value damage is calculated. The present value damage calculation sums the AAD that is expected to occur for each of the 50 years being considered in this study. However in order for the damage value in each year to be comparable with each other they are discounted to represent the equivalent present damage value. Discounting damage values in the future is based on the principle that generally people prefer to receive goods or services now rather than later. This is known as time preference. The cost therefore of providing a flood management option will also be discounted to present day values. It is therefore best practice to discount the AAD figure for any given year by the distance in years it is away from the present day. The OPW has set this discount rate at 4% and this figure has been used in this study. Over the 50 years being considered this amount to factoring the AAD by 22.341. The AAD and PVD are calculated for the direct damages, intangible damages and the emergency costs separately and totalled to give the overall damage available.

The AAD calculations consider damages up to the 0.1% AEP flood event. However when considering the FRM methods to alleviate this risk the standard of protection will usually be to the 1% AEP flood event. It is therefore useful to calculate the AAD up to the 1% AEP flood event as well. This becomes useful when considering residual risk. For more details on FRM methods and standards of protection see chapter 6. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.8 - AAD and pvD data

| Data type   | Attribute name   | Data details   |
|---|--|--|
| Annual Average<br>Damage for direct<br>damages,<br>intangible<br>damages and<br>emergency costs | AAD,<br>AAD_Int,<br>AAD_emerg,<br>AAD_Q100,<br>AAD_Int100,<br>AAD_eme100 | The equation to calculate the AAD is as follows: $ (Q2\_Dm€13+Q5\_Dm€13)/2*(0.5-0.2)+(Q5\_Dm€13+Q10\_Dm€13)/2*(0.2-0.1)+(Q10\_Dm€13+Q20\_Dm€13)/2*(0.1-0.05)+(Q20\_Dm€13+Q50\_Dm€13)/2*(0.05-0.02)+(Q50\_Dm€13+Q100\_Dm€13)/2*(0.02-0.01)+(Q100\_Dm€13+Q200\_Dm€13)/2*(0.01-0.005)+(Q200\_Dm€13+1000\_Dm€13)/2*(0.005-0.001) $ |
| Present value damage  | pvD,<br>pvD_Int,<br>pvD_emerg,<br>pvD_Q100,<br>pvD_Int100,<br>pvD_eme100 | The AAD factored by 22.341   |

#### 5.9 CAPPING DAMAGES

It is recognised that for certain properties the overall damage associated with it can far exceed the market value of the property. This can be due to either the depth to which it floods or the frequency with which it floods or more likely a combination of both. Where such a situation occurs it is necessary to cap the damages at the market value. The market value was calculated at a regional level with the market value data sourced from CSO.

Properties affected by the River Poddle have been assigned a market value of €320,728 which is the regional average market value of second hand properties for Dublin taken during the first quarter of 2013. Damage to commercial properties were reviewed to ascertain the proportion any individual commercial property has on the overall damage. For properties contributing to 1% of the total damage or more a detailed assessment was carried out. This involved confirming the amount of floor area that would flood and the FFL assumed. For the River Poddle no commercial properties contributed 1% of the damage or greater.

The approach taken in this study is to cap the direct damages and the intangible damages separately before totalling up the overall damages with the emergency costs. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.9 - Capping damages data

| Data type                                | Attribute name                                       | Data details                                       |
|--|--|--|
| Capped damages for direct and intangible | pvD_Cap,<br>pvDInt_Cap,<br>pvD_Q100cp,<br>Int100_cap | Any damages over €320,728 are capped at this value |

#### 5.10 DAMAGE ASSESSMENT REVIEW

A review of the damage assessment was carried out to quality check the data being used. This was carried out by reviewing the properties that contribute over 1% of the capped pvD. The review consists of checking the property type and the finished floor level including split levels, the footprint areas and the depth damage being applied.

#### 5.11 SUMMARY OF DAMAGES ON THE RIVER PODDLE STUDY

The last field in the attribute table of the economic risk shapefile is the total damage which sums the capped present value direct damages, the capped present value intangible damages and the present value emergency costs. This gives the overall present value damage. The table below summarises the damages associated with the River Poddle Study.

Table 5.10 - Summary of damages on the River Poddle Study

| Total AAD  | Total AAD up to 1%<br>AEP event | Total pvD   | Total pvD up to the 1% AEP event |
|------------|---------------------------------|-------------|----------------------------------|
| €1,158,696 | €927,534                        | €22,793,840 | €17,838,864                      |

## 6 FLOOD RISK MANAGEMENT METHODS

There are various ways to manage the flood risk within any area being studied. These methods can be grouped into 4 areas.

- Protect methods reduce the likelihood of flooding. Methods include flood walls, flow diversion and upstream storage.
- Prepare methods reduce the impact of flooding. Methods include individual property protection, flood forecasting and public awareness campaigns.
- Prevent methods avoids future flood risk. Methods include planning and development control
- Permit methods accepts that flooding will occur. Methods include maintaining the existing regime and doing a minimal amount of maintenance.

The CFRAM study has set an objective to identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Area being studied. With this being said it is an aspiration of the study to provide the highest standard of flood risk management that is cost beneficial. This would, in general, entail providing 'protect' methods over 'prepare' methods and avoiding 'permit' methods where possible. Prevent methods, which consider future flood risk, should always be included.

#### 6.1 STANDARD OF PROTECTION

The standard of flood risk management is also dependant on the design standard being applied i.e. the maximum level of protection that the FRM methods provide. The preferred design standard for this study is the 1% AEP event for fluvial flood risk and the 0.5% AEP event for coastal flood risk or the appropriate combination for areas of joint fluvial-coastal influence. The FRM method achieving the design standard must also have provision for adaptability to the mid range future scenario (MRFS) flood risk.

Where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate or acceptable, or where the adoption of alternative standards would provide significant additional benefit in relation to costs and impacts, this is also considered.

#### 6.1.1 Residual Risk

For any FRM measure the flood risk to an area being studied can never be totally eliminated as a flood event greater than the design standard can occur, this is referred to as residual risk. In calculating residual damage it is assumed that for any design standard less than the 0.1% AEP flood event, residual damage will occur. In most cases the design standard will be to the 1% AEP event and there will therefore be residual damage for the 0.5% and 0.1% AEP flood events. For the purposes of this study it is assumed that for FRM methods that contain the flow within the river channel, such as flood walls, the residual damage for flood events greater that the design standard will be the same as the present day current damages. For FRM methods that reduce the flow, such as upstream storage, a benefit will be provided during flood events greater than the design standard event and therefore should be calculated.

#### 6.2 LIST OF FRM METHODS

The following table lists the FRM methods being considered in the Eastern CFRAM Study. This list is not exhaustive and additional FRM methods may become apparent which are specific to an area being studied. Where this is the case the additional FRM methods will be added to the long list of methods to be screened.

**Table 6.1 FRM Methods** 

| FRM Method                             | Method type | Description  |
|--|-------------|--|
| Do Nothing                             | Permit      | Implement no new flood risk management measures and abandon any existing practices.  |
| Maintain Existing<br>Regime            | Permit      | Continue any existing flood risk management practices, such as reactive maintenance.   |
| Do Minimum                             | Permit      | Implement additional minimal measures to reduce the flood risk in specific problem areas without introducing a comprehensive strategy.   |
| Planning and Development Control       | Prevent     | Zoning of land for flood risk appropriate development, prevention of inappropriate incremental development, review of existing Local Authority policies in relation to planning and development and of inter-jurisdictional co-operation within the catchment.   |
| Building Regulations                   | Prevent     | Regulation relating to floor levels, flood proofing, flood resilience, sustainable drainage systems, prevention of reconstruction, or redevelopment in flood risk areas.   |
| Catchment Wide SuDS                    | Prevent     | Implement attenuating infrastructure to the existing drainage system in order to reduce the flow entering the river network. This may consist of swales, french drains, soak aways, larger culverts, underground storage tanks, ponds, green roofs, etc.   |
| Emergency Response<br>Plan             | Prevent     | Using the Flood mapping, various reports and proposed flood risk management measure to review and update their Emergency Response Plans  |
| Land Use<br>Management                 | Protect     | Changing how the land is used in order to store or slow surface water runoff and slow in channel and out of bank flow along the river in order to store flood water in suitable locations. This may consist of the creation of wetlands, restoring river meanders, increasing the amount of boulders and vegetation in channel, perpendicular hedges or ditches in the floodplain, tree rows and planting in floodplain to either slow flow or direct flow, planting along banks parallel to flow, fencing off livestock from riparian strip, changing agricultural practices to decrease soil compaction and increase water infiltration. |
| Strategic<br>Development<br>Management | Prevent     | Management of necessary floodplain development (proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and/or protection systems.   |
| Maintenance<br>Programme               | Protect     | Increased frequency of routine maintenance, targeting of problem culverts, bridges or other control structures, removal of debris and rubbish tipping, desilting of sedimentation prone areas.   |
| Upstream<br>Storage/Storage            | Protect     | Large scale dam and reservoir, offline washlands (embanked areas of floodplain to store water during larger flood events.  |
| Tidal Barrage                          | Protect     | A fixed or moveable barrier across the river to prevent tidal water progressing upstream.  |
| Improvement of<br>Channel Conveyance   | Protect     | Deepening of channel bed, widening of channel, realigning long section profile, removal of constraints, lining or smoothing channel.   |
| Hard Defences                          | Protect     | Reinforced concrete walls, earth embankments, demountable barriers.  |
| Relocation of<br>Properties            | Protect     | Abandoning flood risk area and properties within and providing alternative properties in suitable area.  |

| FRM Method                             | Method type | Description  |
|--|-------------|--|
| Culverting                             | Protect     | Routing the watercourse underground through culvert to prevent out of bank flooding along a specific stretch.  |
| Diversion of Flow                      | Protect     | Removing flow from the watercourse via a diversion and discharging to a suitable river or coastline or reintroducing the flow further downstream. This may consist of a culvert or an open channel.                          |
| Overland Floodways                     | Protect     | Using topographical features of the floodplain to convey out of bank flow and discharge to other suitable rivers, the coast line or further downstream on the same river. This may consist of fields, park land, roads, etc. |
| Sealing Manholes                       |             | Preventing pressurised culverts from surcharging through manholes and flooding the surrounding area.   |
| Rehabilitation of<br>Existing Defences | Protect     | Improvement of existing flood defences.  |
| Localised Protection<br>Works          | Protect     | Minor raising of existing defences/levels, infilling gaps in defences, etc.  |
| Flood<br>Warning/Forecasting           | Prepare     | Installation of flood forecasting and warning system and development of emergency flood response procedures.   |
| Public Awareness<br>Campaign           | Prepare     | Informing public who live, work or use a flood risk area on risks of flooding and how to prepare for flooding.   |
| Individual Property<br>Protection      | Prepare     | Flood protection and resilience measures such as flood gates, vent covers, use of flood resilient materials, raising electrical power points, etc  |

#### 6.3 BASELINE CONDITION

The FRM method "maintain existing regime" is considered the baseline condition as is described in table 6.1 above. This represents the current scenario which all other scenarios, created by the implementation of other FRM methods, are compared to. This is realised by the reduction in receptors at risk, as described in chapter 4, and the reduction in monetary damage (see chapter 5) also known as benefit.

#### 7 ASSESSMENT OF FRM METHODS

In order to ensure a consistent approach across the whole Eastern CFRAM study area, a process to assess the FRM methods for each SSA has been standardised as summarised in the flow chart below.

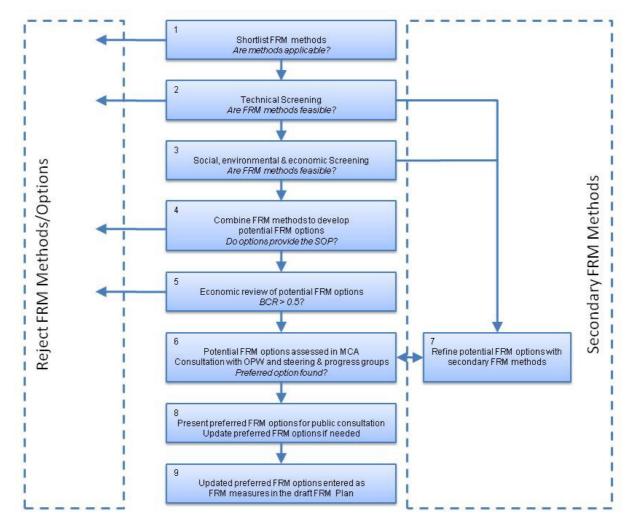


Figure 7.1 - Assessment of FRM methods flow chart

The flow chart summarises in boxes 1 to 3 how the screening of FRM methods is carried out. Boxes 4 and 5 describe how the feasible FRM methods that come through the screening are developed into potential FRM options and box 6 shows how the potential FRM options are assessed to identify the preferred FRM options. This process is carried out in consultation with the OPW and the steering group and progress groups of the Eastern CFRAM Study. If however no preferred FRM option is identified, box 7 shows how the options can be refined with additional or other FRM methods and reassessed. The preferred FRM options are then taken forward to public consultation and, if required, updated to reflect the comments and issues raised before presenting the final FRM measure in the FRM Plan as shown in boxes 8 and 9. Appendix B provides a record of the assessments and decisions made when this process was applied to the Poddle.

#### 7.1 SCREENING FRM METHODS

The aim of the screening process is to ensure the widest possible range of FRM methods are considered in the assessment process while the rejection of any methods shall be robust and with

clear and transparent reasoning. The following section details how the screening process achieves this.

#### 7.1.1 Shortlisting FRM Methods

A long list of FRM methods (Table 6.1) has been developed by OPW and RPS and includes FRM methods which reduce the likelihood of flooding (protect measures), reduce the impact of flooding (prepare measures) and avoid future flood risk (prevent measures).

This long list is reviewed for each SSA in terms of applicability. Measures which are not applicable to the specific SSA are rejected and a shortlist of FRM methods created to be considered further. An example of this is considering flood forecasting at an AFA SSA. If the flood forecasting were to benefit multiple AFAs, the full benefit of the FRM method would not be captured at an AFA scale of assessment and would therefore be considered only at UoM scale or Sub-Catchment scale. For more information on SSAs see chapter 3. The full list of possible FRM methods along with a description of each is presented in chapter 6.

#### 7.1.2 Technical Screening

Although an FRM method may be applicable, it may not be feasible from a technical point of view. This may be due to the method providing no reduction in flood risk. An example of this is where a high level of maintenance and operation is currently being carried out on the watercourse and to implement the "do minimum" method, (a reduction on maintenance and operation) would result in increased flood risk with little cost savings. Where such methods are identified they are rejected at this stage and not considered any further in the process.

Other methods may have little impact in reducing the flood risk. A flood warning system on a flashy watercourse may not be effective, and though it may be beneficial to some degree, it would not be effective as a primary method. Where such methods are identified they are classed as a secondary method. Secondary methods are methods which have been identified as unsuitable to manage the flood risk as a primary method but do not merit complete rejection from the assessment process. These secondary methods are "parked" until the primary options refinement stage. A situation where this could arise is when hard defences have been identified as the primary method but, for example due to complex access along the watercourse, it may be better to culvert a short reach where hard defences would be unsuitable.

The technical screening also identifies methods which would be excessively complex to implement. This may be due to restrictions on construction methods or obstacles such as bridges and underground services. These methods may be effective in reducing the flood risk but due to their complex nature do not merit further consideration until all other more straightforward methods have been exhausted. These methods are also classed as secondary methods.

Methods which upon review are found to be relatively straightforward and have a noticeable impact in reducing the flood risk are classed as primary methods and are taken through to the next stage of the assessment process.

#### 7.1.3 Environmental and Social Screening

It is important to ensure that methods being brought through the assessment process will not have significant detrimental environmental, social/cultural or economic impacts. To this end each primary method progressing through the technical screening is assessed from an environmental, social/cultural and economic criteria in turn.

The following rationale are considered when developing the methodology for screening methods in relation to their potential to impact on environmental, social and cultural receptors:

- The methodology must be robust and defendable;
- The methodology must be rapid and replicable;
- The methodology must be precautionary to avoid rejecting methods at an early stage which might
  prove to be the best available method manage flood risk;
- The methodology must not overlap the multi-criteria analysis and environmental assessment processes.

In order to fulfil these aims, the methodology considers whether the method is likely to have a direct or indirect negative effect on Special Areas of Conservation (SACs), Special Protection Areas (SPAs) or Unesco sites.

- If there are no SACs, SPAs or Unesco sites within the footprint of the proposed method, directly adjacent to the proposed method, or directly upstream or downstream of the proposed method, then the method can continue through the screening process as a primary method.
- If an SAC, SPA or Unesco site is within the footprint of the proposed method, directly adjacent to
  the proposed method or directly upstream or downstream of the proposed method, then the
  method cannot be considered as a standalone method at this stage and is classed as a secondary
  method.

This methodology ensures that when a method has been flagged as potentially having a negative impact on an SAC, SPA or Unesco site, the optioneering team will put the method aside and consider other methods which have not been flagged in terms of environmental, social or cultural impacts first.

#### 7.1.4 Economic Screening

The economic screening aims to ensure that only methods likely to be cost beneficial will progress to the more detailed assessment. This is carried out by calculating the benefit available and comparing that to the cost of implementing the method. The benefit available is quantified through the damage assessment as described in chapter 5. Benefit is a monetary measurement and considers the reduction in damage between the baseline condition (maintain existing regime, see chapter 6) and the FRM method or option being considered. In practice the benefit usually equates to the baseline condition damage up to the design standard of the FRM method/option being considered plus the reduction in residual risk beyond the design standard, see chapter 6 for details on residual risk.

In order to ensure that the screening process is conservative, only the construction cost associated with the FRM method in question is considered. Costs associated with other works such as design and maintenance of the FRM method are excluded at this stage. This allows more FRM methods to pass through the economic review to be assessed in more detail later. A ratio between the benefit and construction cost provides the basis for screening out methods. FRM methods achieving a benefit cost ratio (BCR) of 0.5 or greater are considered further. Setting the minimum BCR at 0.5 recognises that when FRM methods are developed into FRM options, the quantities (i.e. length of flood wall etc) of any given FRM method can change and therefore the BCR. A BCR of 0.5 is therefore a conservative approach while still identifying excessively expensive methods. FRM methods achieving less that 0.5 are classed as secondary methods as they are unlikely to result in a cost beneficial scheme. The following section details how the construction costs of FRM methods are estimated.

#### 7.1.5 Construction costs

The cost of constructing FRM methods is calculated using data from OPW, local authorities, the Environment Agency and RPS. This data is based on previous schemes using real costs and is presented as rates to be applied to the FRM methods depending on the quantities involved.

As such the first stage in this process is to quantify the FRM methods. This information included wall lengths and heights, lengths of culvert, volume of embankments, etc. This is carried out by hydraulic modelling and using the GIS software ESRI ArcMap. The location and extent of FRM methods are delineated in GIS using OSi mapping with consideration of the flood risk receptors. Once finalised the design standard flood event is simulated with each FRM method in place in a hydraulic model and the heights required calculated. This can sometimes be an iterative process.

Once the quantities are calculated, the construction rates can be applied to estimate the cost. For details of the Poddle FRM methods costs see appendix C.

### 7.2 DEVELOPING POTENTIAL FRM OPTIONS

The primary FRM methods which are progressed through the technical, environmental, social and economic screening are combined to create potential FRM options. Most methods, while providing significant reductions in flood risk, will not manage the flood risk entirely by themselves. Methods are therefore required to be combined into options so that they will manage the flood risk and achieve the objectives set by the study. In most cases the FRM options are required to provide a design standard of the 1% AEP flood event although this can vary depending on the requirements of the SSA. All

possible combinations of FRM methods are considered as potential FRM options, however, only options that can provide the required design standard are progressed further.

#### 7.2.1 Economic review of Potential FRM options

A further economic review is carried out to ensure that a BCR of greater than 0.5 is still being achieved as it is possible that combining FRM methods can lead to an excessively costly option being created that is unlikely to be cost beneficial. This economic review is similar to that described in section 7.14 using the same benefit value as previously calculated. The costing of the option is carried out in more detail. Costs additional to those for construction are included to give a more accurate estimate of the overall cost of the option. The following items are included in the option costing.

Table 7.1 - Additional costs to FRM options

| Item   | % of construction cost |
|--|------------------------|
| Provision for unmeasured items   | 20                     |
| Provision for optimism bias  | 60                     |
| Maintenance costs (PVD over 50yrs)                                       | -                      |
| Detailed design (design fees)  | 6                      |
| Construction supervision   | 5                      |
| Allowance for archaeological and/or environmental monitoring/exploration | 21                     |
| Cost of land acquisition/compensation                                    | 12.5                   |
| Allowance for art  | 1                      |

Details of the costing of the FRM options are presented in appendix C

#### 7.3 ASSESS POTENTIAL FRM OPTIONS (MCA PROCESS)

The potential FRM options which are progressed to this stage are found to be technically, socially, environmentally and economically feasible. In assessing the potential FRM options the best, most appropriate option which has been found feasible by the preceding stages is identified.

The assessment of FRM options in the past has been primarily based on economic costs and benefits, with an EIA undertaken to minimise negative impacts on the environment, and public consultation undertaken to ensure social acceptability. The National Flood Policy Review (OPW, 2004) set a broader range of objectives for flood risk management in Ireland, that was subsequently reinforced by the EU 'Floods' Directive [2006/60/EC].

The MCA framework has been developed to broaden the range of potential impacts associated with flooding and the implementation of FRM options considered in the development and selection of FRM options and strategies, and their subsequent prioritisation. It is based on the numeric, but non-monetarised, assessment of options against a range of objectives. Indicators are used to assign scores for each objective on the basis of the degree to which the option being appraised goes beyond a specified basic requirement for that objective towards meeting a specified aspirational target for that objective. Weightings are applied globally (nationally) for each objective, with local weightings applied to reflect the local importance of that objective in the context of the respective SSA, and these weightings are applied to the scores derived as described above.

The sums of the weighted scores, set against the total costs of their achievement, represent the preference for a given option (using all criteria) or the net benefits of an option (using only the economic, social and environmental criteria). These total scores can be used to inform the decision on the selection of (a) preferred option(s) for a given location and the prioritisation of potential schemes between locations.

The following section describes the MCA process in more detail.

#### 7.3.1 Criteria and Objectives

Each option is assessed against four criteria; Technical, Economic, Social and Environmental. Scoring against these criteria helps to achieve the CFRAM Study objective of achieving the most cost effective and sustainable management of existing and potential future flood risk within the area being studied. A set of objectives are associated with each criteria and are an expansion on the requirements of the National Flood Policy Review and the EU Floods Directive. The degree to which an option achieves each objective is an indication of the success of the option in managing the flood risk, the more the option achieves across all the objectives, the greater preference it will be given.

Generally each objective focuses on a flood risk receptor type and how the flood risk is to be reduced with the exception of the technical objectives which focus on how the options would be constructed and operated during their lifetime. In some cases the flood risk receptor type is wide reaching and sub-objectives are required to focus on a specific group within the receptor type. The table below presents the objectives and sub-objectives set for each of the criteria in the MCA.

Table 7.2 - Criteria and Objectives of the MCA

| Criteria      | Objective  | Sub-Objective  |  |
|---------------|--|--|--|
| Technical     | Ensure flood risk management options are operationally robust  | Ensure flood risk management options are operationally robust  |  |
|               | Minimise health and safety risks associated with the construction and operation of flood risk management options | Minimise health and safety risk associated with the construction an operation of flood risk managemer options                        |  |
|               | Ensure flood risk management options are adaptable to future flood risk  | Ensure flood risk management options are adaptable to future flood risk  |  |
| Economic      | Minimise economic risk   | Minimise economic risk   |  |
|               | Minimise risk to transport infrastructure  | Minimise risk to transport infrastructure  |  |
|               | Minimise risk to utility infrastructure  | Minimise risk to utility infrastructure  |  |
|               | Manage Risk to agricultural land   | Manage Risk to agricultural land   |  |
| Social        | Minimise risk to human health and life   | Minimise risk to human health and life of residents  |  |
|               |  | Minimise risk to high vulnerability properties   |  |
|               | Minimise risk to community   | Minimise risk to social infrastructure   |  |
|               |  | Minimise risk to local employment  |  |
|               | Minimise risk to flood-sensitive social amenity sites  | Minimise risk to flood-sensitive social amenity sites  |  |
| Environmental | Support the objectives of the WFD  | Prevent deterioration in status, and if possible contribute to the achievement of good ecological status / potential of water-bodies |  |
|               | Minimise the risk to potential sources of environmental pollution  | Minimise the risk to potential sources or environmental pollution  |  |
|               | Support the objectives of the Habitats Directive   | Avoid damage to, and where possible enhance, European protected Natura 2000 sites  |  |
|               | Avoid damage to, and where possible enhance, the flora and fauna of the catchment                                | Avoid loss/damage to, and where possible enhance, nationally protected sites of nature conservation importance i.e. (p)NHA, Ramsar   |  |
|               |  | Avoid loss / damage and where possible enhance, legally protected species and other known species of conservation concern            |  |

| Criteria | Objective   | Sub-Objective   |
|----------|---|---|
|          | Protect, and where possible enhance, fisheries resource within the catchment                                      | Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species |
|          |   | Protect, and where possible enhance, the quality of shellfish waters  |
|          | Protect, and where possible enhance, landscape character and visual amenity within the river corridor             | Protect, and where possible enhance, visual amenity   |
|          | Avoid damage to or loss of features of cultural heritage importance and their                                     | Avoid damage to or loss of features of architectural value and their setting  |
|          | setting   | Avoid damage to or loss of features of archaeological value and their setting   |
|          | Protect soil function   | Avoid loss of soil from erosion   |
|          | Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities | Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities   |

#### 7.3.2 Scoring Options

A scoring system is devised for the MCA to assess each option in a robust, clear and transparent way. A score is given for how well an option achieves an objective but also accounts for the importance of the objective relative to other objectives and how important the receptors within the area being studied are relative to the receptor group being considered.

To enable the scoring of the objectives, indicators are set. Indicators are parameters, measurable and numeric where possible, by which the success of the option in meeting a particular objective can be gauged. For example a social objective is to "minimise risk to human health and life of residents" and the indicator is "the number of residential properties at risk from flooding during the 0.1% AEP event". The difference that the option being assessed makes to the number of residential properties at risk can be calculated as a percentage and applied to the maximum score value to give the score.

The success of the option in achieving the objective in question is quantified by how much it goes beyond a specified basic requirement and achieves a specified aspirational target. As such basic requirements and aspirational targets have been set in terms of the defined indicator.

The basic requirement represents a neutral status or 'no change', whereby an option has no impact on the matter the objective relates to, or meets what might be termed for some objectives as minimum requirements for acceptability. If an option performs less well than than the basic requirement, i.e. has a negative impact (a dis-benefit) or does not meet the minimum requirements for acceptability, it will score a negative-value score for that objective, but might still be considered further, depending on the degree of the dis-benefit or failure to meet the requirements. The basic requirement is therefore not an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance.

The aim of an objective is defined by the aspirational target, whereby an option would be deemed as performing optimally with respect to the given objective if it were to meet the aspirational target. Typically this will represent complete removal of a risk, or the full achievement of another benefit, and it will be rare that any option will meet such aspirational targets for even one, let alone all, objectives. The aspirational targets are therefore not requirements that must be met, and it should be noted that very effective options may still fail to meet the aspirational targets.

The following rules have been applied to the MCA scoring:

- An option achieving the basic requirement is given a score of zero
- An option meeting the aspirational target is given a score of five. Options achieving more than the aspirational target still score a maximum of five.

 An option achieving somewhere in between the basic requirement and the aspirational target is given a score proportional to the degree to which it achieves the objective beyond the basic requirement towards meeting the aspirational target.

- An option failing to meet the basic requirement is given a negative score of -1 to -5 depending on the impacts associated with the options.
- Where the performance or impact of the option becomes unacceptable a score of -999 is given and the option is rejected from further consideration.

Justification for each objective score has been included within the MCA tables providing the rationale for each score.

#### 7.3.3 Weighting objectives

It is appreciated that some objectives are more important that others and to give them all equal importance would not reflect the real benefit, or lack thereof, achieved. For example, an objective considering risk to life is more important that one considering social amenity sites. To reflect this in the scoring a global weighting has been applied. This gives an objective more or less weight in the overall assessment of the suitability or value of the option. Global weightings will remain constant nationally and were derived following consultation carried out on previous pilot studies and with OPW and a number of environmental stakeholders.

It is further appreciated that for any given objective its importance will depend on the SSA and the type of receptor it is considering. For example, an objective considering the impact to environmentally designated sites may have more significance if the site is of international importance than of local importance. To account for this a local weighting is applied to the objective. The local weighting has been determined numerically according to the degree of risk (e.g. annual average damage, number of properties, etc) but some have been set by professional judgment. Details of the local weighting rationale are included within the MCA tables.

#### 7.4 PREFERRED FRM OPTIONS

Identification of the preferred FRM options is based on the following:

- Benefit Cost Ratio (BCR) The ratio between the monetary benefit of adopting a FRM option and the overall cost of constructing, operating and maintaining the option. A ratio of one or greater must be achieved for an option to be considered further.
- MCA score The sum weighted score of all of the objectives set in the MCA. This score represents the non-monetary benefit of adopting the FRM option
- Overall Net Benefit/Cost This is a ratio between the non-monetary benefit of adopting a FRM option and the overall cost of constructing, operating and maintaining the option.

Professional judgement is required to identify the preferred options as some options may have a good monetary BCR but a poor overall net benefit/cost or vice versa and comparison between options may not always be clear. Where preferred options are identified the baseline condition can be removed from further consideration. If no preferred options are identified the baseline condition will remain as a preferred option.

Preferred FRM options are reviewed by OPW and the Eastern CFRAM Study progress group and steering group members. Recommendations can be made at this point by these groups to improve the options.

#### 7.4.1 Refining options

If no preferred option is identified, or recommendations are made during the consultation with the OPW and the Eastern CFRAM Study progress group and steering group members, a refinement of the potential FRM options can be carried out. This process allows for secondary methods, previously "parked" as shown in figure 7.1, to be considered in strategic places in order to reduce the costs, or address particular social, environmental or technical issues. The refinement process also allows for a lower SoP to be considered if it is clear that no options is feasible to protect to the preferred SoP. For

each refined option considered, an MCA and cost benefit analysis are carried out and the revised score assessed to see if a preferred FRM option is achieved.

#### 7.5 PREFERRED FRM OPTIONS FOR THE RIVER PODDLE

The table below details the potential FRM options and the FRM methods that each option consists of. The potential FRM options were reviewed by OPW and the progress and steering groups and all progressed to preferred FRM options for consultation.

Table 7.3 - Preferred FRM Options progressed to Public Consultation

|          | FRM Methods   |                  |                             |
|----------|---------------|------------------|-----------------------------|
| Option 1 | Hard defences | Sealing manholes |                             |
| Option 2 | Hard defences | Sealing manholes | Upstream<br>storage/storage |
| Option 3 | Hard defences | Sealing manholes | Diversion of flow           |

The breakdown of how each FRM option scored during the MCA is detailed in table 7.4 below

Table 7.4 - Preferred FRM Options MCA score breakdown

|                     | Option 1 | Option 2 | Option 3 |
|---------------------|----------|----------|----------|
| Technical score     | 500      | 1,100    | 600      |
| Economic score      | 820      | 820      | 820      |
| Social score        | 640      | 640      | 640      |
| Environmental score | 115      | 80       | -135     |
| Overall score       | 2,075    | 2,640    | 1,925    |

It can be seen that all three options achieved the same economic and social scores. This is due to all options protecting the same receptors to the same standard of protection. Each option would however impact on the environment to varying degrees. This mainly centred around the river's water status under the Water Framework Directive (WFD). Each option also varied in their technical score which accounts for the complexity during construction, operation and maintenance.

Details of the screening of FRM methods, developing FRM options and assessing FRM options are presented in appendix B. Sketches of these options are presented in appendix D

#### 8 CONSULTATION AND UPDATING PREFERRED FRM OPTIONS

An important element of the Eastern CFRAM Study is consultation with all interested parties including the public. This is carried out at strategic points in the study, including the identification of preferred FRM options. This gives the interested parties an opportunity to communicate local knowledge and how they are currently affected, and to give their views on the preferred FRM options, thereby influencing the decision-making process.

The consultation includes a wide range of interested parties with general or specific interests such as impact on society, the environment, cultural heritage or the economy. All comments are considered and, where relevant, further updates to the options can be carried out before the final FRM measure are presented in the FRM Plans.

#### 8.1 CONSULTATION RECOMMENDATIONS FOR THE RIVER PODDLE

Consultation was carried out through elected members briefings, a stakeholders workshop, public consultation days and correspondence with the Local Authorities and the OPW. Web-based consultation was also undertaken. Details of the consultation can be found in the Camac and Poddle HPWs Consultation Synthesis Report (Ref). The following summarises the main findings from the consultation activities regarding the options proposed.

- Most people who attended events had experienced flooding and consequently would be happy to see any kind of flood defence along the River Poddle and are keen to get something in place as soon as possible.
- Options 2 and 3 (options with the Tymon Park storage and the flow diversion respectively) are generally preferable to option 1 with just hard defences. There was no clear preference between options 2 and 3 but the concerns expressed during the public consultation over the potential flood impact along the River Dodder, with the strong objections from some elected members, indicates that option 3 is less socially preferable, despite option 3 being economically preferable
- It was stated that a main cause of flooding during the October 2011 flood was due to blocked culverts. Maintenance and keeping culverts clear are a major concern to the River Poddle residents. For many people, any option which does not address the problem of culvert blockages is unacceptable and options which remove the need to rely on maintenance should be sought.
- There was concern that any of the FRM options proposed would have an adverse impact on the pluvial flood risk.
- OPW recommended that LAs use the Flood mapping, various reports and proposed flood risk management measure to review and update their Emergency Response Plans

The comments from the consultation process were reviewed and the following was carried out:

- OPW commissioned RPS to carry out an additional culvert blockage analysis study. This
  study aims to identify the culverts at risk of blocking and would cause a significant flood risk
  and propose FRM measures to mitigate this risk.
- A maintenance review of the River Poddle was carried out to identify any maintenance measures required.
- A study on the impact to the River Dodder was carried out assuming option 3 (flow diversion) were to be implemented and any mitigation measures required were proposed.
- An analysis of the impact of FRM option to the pluvial flood risk was carried out

#### 8.2 CULVERT BLOCKAGE ANALYSIS

The Poddle culvert blockage study was used as a pilot to develop a method to assess culvert blockages. Option 2 (Tymon Park storage) and option 3 (flow diversion to the River Dodder) were identified as the most preferable during the consultation. Of these two options, option 2 produces the

largest flows in the River Poddle and was therefore used in this analysis as it would create the most onerous scenarios. The following section details the results of this analysis.

The culvert blockage analysis identified five culverts as being likely to block and could cause significant flood risk and damage. Each culvert was assessed individually and the effect it would have on the surrounding area considered. The damage caused by culvert blockages if option 2 were in place was assessed to the same standard as described in section 2.3.2 and the increased damage is detailed in the table below.

Table 8.1 - Increased present value damage caused by culvert blockage

| Culvert                     | pv Damage within area of influence - Clear Screen | pv Damage within area of influence - Blocked Screen | Increased<br>Direct<br>Damage |
|-----------------------------|---|---|-------------------------------|
| Kimmage Manor<br>Culvert    | €0  | €0  | €0                            |
| Poddle Park<br>Culvert      | €262,317  | €1,110,210  | €847,893                      |
| Sundrive Road<br>Culvert    | €9,889,045  | €10,854,013   | €964,968                      |
| Mount Argus Park<br>Culvert | €232,852  | €13,077,845   | €12,844,994                   |
| Harolds Cross<br>Culvert    | €0  | €7,011,465  | €7,011,465                    |
|                             |   |   | €21,669,320                   |

It can be seen in the table above that substantial damage can be caused if the culverts listed above were to block to the extent assumed. The culvert at Kimmage Manor produces no damage during the design event whether the culvert blocks to the assumed degree or not. From the assessment it was found that although the culvert blockage caused extensive flooding in that area, the FFLs were sufficiently high to avoid any damage to the properties. There will therefore be no benefit in mitigating against this risk.

An assessment on how to mitigate culvert blockages was carried out. In most cases a flood wall is proposed on both banks of the River Poddle approaching the culvert inlet as well as providing a head wall at the culvert. This tells us that even when the culverts are running clear the channel is at capacity and walls would be required to prevent out of bank flooding. While upgrading or installing new trash screens are also recommended they cannot be considered to mitigate the flood risk caused by blockages completely. This is due to all trash screens having the potential to collect a build up of debris during a flood event which will cause raised water levels upstream. While the impact would not be as severe as the current situation at each culvert it would still rely on human intervention to clear the screens and if the channel is at full capacity could not provide a complete solution by itself.

It was assumed that the method to manage this increased risk was to increase the height and length of the proposed upstream flood walls and provide suitable trash screens. The table below summarises the changes required to achieve this.

Table 8.2 - Changes required to mitigate blockage flood risk and BCR

| Culvert                     | Measure  | Increased<br>Cost |
|-----------------------------|--|-------------------|
| Harolds Cross<br>Culvert    | Additional walls required at Mount Jerome Cemetry and Gandon Place approximately 310m in length and up to 2.1m high and also at Mount Argus Road adjacent to the church approximately 90m in length and up to 2.1m high. A screen upgrade is required at the Harolds Cross culvert to reduce the likelihood of blockage. | €2,324,280        |
| Mount Argus<br>Park Culvert | Walls and embankments required at Mount Argus Estate 335m in length and up to 2m high. A trash screen is required at the Mount Argus Park culvert to reduce the likelihood of blockage.  | €1,376,930        |
| Sundrive Road               | Additional walls required at back of gardens at Blarney Park and   | €1,722,688        |

| Culvert                | Measure   | Increased<br>Cost |
|------------------------|---|-------------------|
| Culvert                | St Martins Park approximately 278m in length and up to 3.1m high. A screen upgrade is required at the Sundrive Road culvert to reduce the likelihood of blockage.   |                   |
| Poddle Park<br>Culvert | Additional walls required at Poddle Park and Fort Field Road approximately 665m in length and up to 3.6m high. A screen upgrade is required at the Poddle Park culvert to reduce the likelihood of blockage | €2,618,505.7      |

The increased benefit (table 8.1) and the increased cost (table 8.2) from mitigating the flood risk caused by culvert blockages was combined with the original figures to assess if a cost beneficial is achievable. This is summarised in table 8.3 below.

Table 8.3 - Comparison of costs and benefits

| Option                          |   | Cost        | Benefit     | BCR  |
|---------------------------------|---|-------------|-------------|------|
| Option 2                        | Hard defences, sealing manholes and upstream storage at Tymon Park                  | €11,412,092 | €17,838,862 | 1.56 |
| Option 2 with culvert blockages | Hard defences, sealing manholes, upstream storage at Tymon Park and screen upgrades | €19,148,216 | €39,428,786 | 2.06 |

It can be seen that a cost beneficial solution is available by combining the culvert blockage mitigation methods to the original option 2. It is assumed that a similar scenario is available for option 3 also.

Further details of culvert blockage analysis can be found in the Poddle Culvert Blockage Analysis Report (ref no IBE0600Rp0023).

#### 8.3 MAINTENANCE REVIEW

It was highlighted during the consultation process that many members of the public have a perception that there is an ongoing maintenance issue along the River Poddle corridor. Problems with rubbish tipping and debris blocking stretches of the open channel and culverts is indeed a recurring problem. While the impact of rubbish tipping is difficult to quantify, it was appreciated that it is a real risk that had not been managed within the preferred FRM options. It was therefore recommended that maintenance be included to the preferred FRM options.

A review of the watercourse was carried out based on the channel survey and correspondence with the relevant Local Authorities. The review has been based on four maintenance criteria which contribute to the flood risk. These four criteria are:

- sedimentation,
- debris.
- vegetation, and
- blockage prone culverts or bridges.

Due to the urbanised nature of the watercourse, high concentration of flood receptors, and that fact that the river is relatively small, it is particularly sensitive to any restriction in flow. It has been noted that some areas are prone to rubbish tipping which can contribute significantly to the flood risk.

Dublin City Council and South Dublin County Council both proactively maintain the River Poddle and have provided additional maintenance and monitoring measures since the October 2011 flood. These measures consist of upgrading culvert screens or fitting new screens at Poddle Park, Sundrive Road and Gandon Hall/Mount Jermoe Cemetry and the installation of CCTV cameras to allow remote monitoring of problem areas.

Nine areas have been identified as areas requiring screen upgrades, increased maintenance and monitoring and are detailed in the figure and table below. For most of the areas identified where

screens and head & wing walls are recommended they are also indentified as part of the blockage analysis recommendations as detailed in section 8.2. The cost benefit analysis for these measures was carried out during the blockage analysis and is not required for this section. The remaining recommendations mainly consist of measures already installed by the Local Authorities or is a recommendation for use of already existing resources. It is therefore assumed that there will be no additional costs to consider.

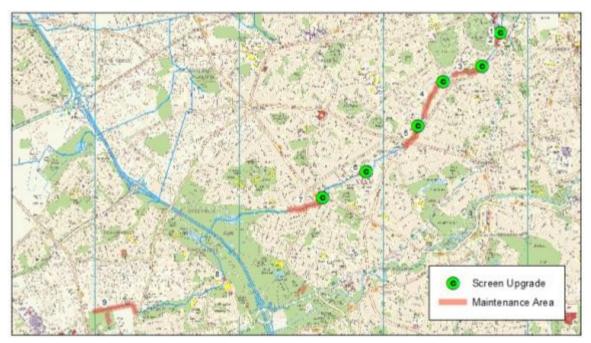


Figure 8.1 - Maintenance areas on the River Poddle

Table 8.3 - Recommended maintenance on the River Poddle

| Maintenance Issue | Comment  | Recommended<br>Action  |
|-------------------|--|--|
| Area 1            | The culvert at Harold's Cross has been identified as at risk of blocking and causing a significant increased flood risk. DCC currently monitor this culvert remotely using CCTV. | Upgrade screen. Extend head and wing walls to contain the water. |

#### **Maintenance Issue** Comment Recommended Action Sedimentation Monitor this stretch Area 2 and debris appear to of watercourse. accumulate upstream of the Mount Argos bridge. Road However due to the high walls there is a large capacity along this stretch of the watercourse. The flood risk would therefore be considered low. Area 3 The culvert leaving • Construct screen. Mount Argos Park at Extend head and Kimmage Road wing walls to Lower has been contain the water. identified as at risk of Secondary blocking and causing Screen at Mount significant Argos Way increased flood risk. • Increased debris Debris has been removal from found in the Mount Argos watercourse Square to upstream of Mount Kimmage Road Argos Park at Mount Lower Argos Way which potentially may contribute to the culvert blockage risk/ Area 4 The culvert • Upgrade screen Sundrive Road has has already been identified as at occurred. risk of blocking and Extend head and causing a significant wing walls to increased flood risk. contain the water. The approach to the Upgrade culvert consists of Secondary open space along St Screen at open Martin's Drive space adjacent to followed by gardens St Martin's Drive. backing on to the • Increased debris river. There is removal from St evidence of debris at Martin's Drive to culvert the and SunDrive Shopping reports of rubbish Centre. tipping in the area. A • Railings along screen small Poddle Park Road

located in the open

described

of

space

upstream

footbridge.

to discourage

tipping.

#### Recommended **Maintenance Issue** Comment Action The culvert at Poddle Area 5 • Construct screen. Park has been Extend head and identified as at risk of wing walls to blocking and causing contain the water. significant Secondary а increased flood risk. Screen in Poddle There have been Park has already reports of rubbish been constructed. tipping at the park • Increased debris and DCC carry out removal in Poddle rubbish regular Park. removal. • Railings along Poddle Park to discourage tipping. Area 6 The culvert at • Construct screen. Kimmage Manor has Extend head and been identified as at wing walls to risk of blocking and contain the water. causing a significant • Remove sediment increased flood risk. and re-profile to The culvert is located ensure self between two recently cleansing channel upgraded culvert bypass screens. There is evidence of sedimentation upstream of the culvert Area 7 The reach of Replace course watercourse between screen and increase Drive debris removal. Wellington (leaving Tymon Park) and Templeville Road was found to have a significant amount of debris. While the flood risk is not significant along this reach it is situated upstream of Whitehall Road and Wainsfort Manor which does. screen is course the located at Templeville Road culvert but is in disrepair.

| Maintenance Issue | Comment   | Recommended<br>Action      |
|-------------------|---|----------------------------|
| Area 8            | There is evidence debris blocking the twin culverts at the school and sports complex in Tymon North. The flood risk here however is not significant.  | Monitor the culvert inlet. |
| Area 9            | The reach of watercourse behind the commercial units at Airton Road is heavily vegetated and could restrict flow and raise water levels accordingly. Properties are at risk in this area and the flood risk could increase as a result of heavy vegetation. | Monitor Vegetation         |

#### 8.4 IMPACT ON THE RIVER DODDER AND SURROUNDING AREA

Introducing additional flow to any catchment can have consequences in relation to increasing the flood risk in that catchment. The River Dodder has a history of flooding and was subject to a pilot CFRAM study. The study found that no cost beneficial solution providing the preferred standard of protection (1% AEP flood event) could be found for the whole of the area being studied. Smaller areas, referred to as flood cells in the Dodder CFRAM Study, were assessed and cost beneficial FRM options identified. The Dodder study has progressed leaving a current scenario where some areas are currently protected due to defences being implemented, some areas not yet protected but defences proposed and some areas at risk during the 1%AEP flood event but no defences proposed.

Adding additional flow from the RIver Poddle could cause additional receptors to be at risk and increase the level of risk to existing receptors located within the Dodder floodplain. To ascertain if this is the case an assessment was carried out to quantify the change in flood depth to receptors.

At the point where the River Poddle flow diversion discharges to the River Dodder, the Dodder Q100 flow is estimated to be 150 cumecs. An estimated additional 3 cumecs coming from the diversion would increase the flow by 2%. To assess this impact a hydrological and hydraulic analysis was carried out and the resulting present day flood extents assessed. It was found that a maximum water level rise of 30mm was estimated during the 1%AEP event.

A review on the potential impact to the properties in the Dodder area was carried out by establishing the current level of flood risk to the properties within the River Dodder area and comparing it to the increased flood risk resulting from the increased flow from the Flood Diversion. The table below summarises the findings.

Table 8.4 - Impact of Flow Diversion on the Dodder area being studied

| Description  | No. of Properties |     |  |
|--|-------------------|-----|--|
| Number of properties currently at risk within existing flood extent with no change in flood depth due to the increased flow from the River Poddle during the 1%AEP flood event | 291               | 700 |  |
| Number of properties currently at risk within existing flood extent with an increased flood depth due to the increased flow from the River Poddle during the 1%AEP flood event | 409               |     |  |
| Number of additional properties at risk due to the increased flow from the River Poddle during the 1%AEP flood event   | 109               |     |  |
|  | 809               |     |  |

From the table it can be seen that 700 properties are currently at risk from a 1%AEP flood event from the River Dodder. The increased flow from the Flood Diversion would result in an additional 109 properties being put at risk along with 409 properties from the current 700 being placed at increased flood risk, due to increased food depth.

The properties affected by the River Dodder can be placed into 3 categories:

- Properties at flood risk in areas where defences are currently constructed
- Properties at flood risk in areas where defences are proposed
- Properties at flood risk in areas where no defences are present or proposed

The following paragraphs discuss the recommended action required if the Flow Diversion were to be constructed.

Areas where defences are currently constructed - The hydraulic models run for this assessment included the existing defences along the River Dodder. These defences protect areas from a 1%AEP fluvial flood event and consist of flood walls. These walls have been afforded a 1m freeboard, well over the recommended 300mm freeboard. This conservative freeboard will be able to accommodate a further increase in water level of 30mm and therefore the potential flood risk to properties located in areas protected by defences has already been mitigated and requires no further action.

**Areas where defences are proposed** - The FRM options proposed for flood cells along the River Dodder consist of flood walls and embankments. To ensure the original proposed level of protection is afforded to all properties an additional 50mm is recommended to be added to design crest height of all defences.

Areas where no defences are present or proposed - There are however some properties located in areas which are not offered any protection existing or proposed which will be subjected to an increased flood risk due to the increased flow from the River Poddle. The increase in flood depth to these properties range from 10 - 20mm. Further mitigation measures will be required to ensure no increase in flood risk as a result of FRM measures from the River Poddle. This may focus on the individual property protection for each building or as a group depending on flood mechanisms and location of properties relative to each other; or flow attenuation along the Flow Diversion or River Dodder such as the Dodder Valley Park or Bushey Park.

The table below summarises these scenarios and the recommendations associated with each.

Table 8.5 - Recommendations to mitigate increased flood risk to Dodder area

| Area type                         | Number of properties at increased flood risk due to diversion from River Poddle | Recommendation   |
|-----------------------------------|---|--|
| Areas currently protected         | 0   | None; freeboard suitable   |
| Areas proposed for protection     | 461   | Additional 50mm to design crest height                                   |
| Areas not proposed for protection | 57  | Further study to ascertain the full extent of flood risk and FRM methods |

This study recognises that there are both perception and technical issue relating to increased levels of risk on the River Dodder that this study cannot fully address, but given the apparent economic merits of the Flow Diversion, the subsequent study should allocate a sufficient body of work to examining and if possible addressing these issues.

#### 8.5 IMPACT ON PLUVIAL FLOOD RISK

Fluvial and coastal flooding can influence the pluvial flood risk in one of two ways. Flood water from the river or coast can enter and surcharge the storm drainage network that it discharges to or the raised water levels in the river or sea prevent the free discharge of surface water and causes the storm water to back up through the drainage system resulting in surcharging and flooding.

Given the perceived pluvial flood risk within the River Poddle area being studied it is important to prevent an increase in pluvial flood risk. As such an analysis was carried out on the two preferred FRM options (option 2 and option 3) to identify areas where this may be the case. A comparison of water levels in the river channel was carried out between each option and the present day scenario. This identified areas where the pluvial flood risk could potentially be increased. This would be due to the increased head that the water in the storm drainage network discharging to the Poddle would have to push against ultimately causing raised water levels within the drainage network. Where no flap valve is present at a discharge point the possibility of fluvial flood water entering the storm drainage network also exists. A review of the storm drainage network discharge point was carried out and while flap valves are present preventing water entering the system there are many without.

The analysis found that an increase in water levels in the River Poddle as a result of both FRM options would occur along the lower reaches up to Mount Argus. It would therefore be recommended that the condition of all storm drainage discharge points in this area be assessed and flap valves fitted if required. In addition to this it may be required that the storm drainage network be upgraded to provide adequate capacity. This analysis would be carried out as part of the detailed design and the MCA and CBA re-scored. However, to give an indication of how this would impact the overall cost benefit ratio the table below shows the result of adding an extra €1 million to the cost of each option.

Table 8.4 - Economic impact of upgrading storm drainage networks

| Option | Description  | Benefit     | Project whole life cost <sup>+</sup> | BCR  |
|--------|--|-------------|--------------------------------------|------|
| 1      | Hard defences and sealing manholes                   | €17,838,862 | €13,672,152                          | 1.30 |
| 2      | Hard defences, sealing manholes and upstream storage | €17,838,862 | €12,412,093                          | 1.44 |
| 3      | Hard defences, sealing manholes and flow diversion   | €17,838,862 | €10,457,249                          | 1.71 |

#### 8.6 UPDATING PREFERRED OPTIONS

The recommendations carried out as a result of the consultation process are to be applied to the preferred FRM options. However as there was no preference given for option 1 (hard defences) during the consultation process and as it scored the worst overall, option 1 was removed from further consideration. The recommendations were therefore applied to options 2 and 3 only and consist of mitigation measures to protect against flooding from culvert blockages at Harolds Cross, Mount Argus Park, Sundrive Road & Poddle Park, installing or upgrading culvert inlet screens, installing flap valves and revising the maintenance plan. Options 2 and 3 are summarised in the following sections.

#### 8.6.1 Option 2 - Hard defences, sealing manholes and upstream storage.

Tymon Park has been identified as a potential storage area using the existing ponds and raising the banks around them to create further storage. The full range of baseline condition flood events were reviewed and it was found that significant flooding starts somewhere between the 50%AEP and 20%AEP flood events. In order for this option to be effective the flow therefore needs to be reduced to the equivalent of the 50%AEP flood event. This measure would be considered effective in significantly reducing the flood risk downstream and within the vicinity of the storage area with a small number of properties at risk upstream of Tymon Park to be addressed separately. However flooding to receptors from the more downstream urban catchment remains to be addressed and therefore this measure will need to be used along with hard defences which would consist of flood walls and earth embankments located where the river banks are low relative to water level. Approximately 2.0km of downstream flood defence would be required with an upstream storage measure. Ancillary works will be required with hard defences such as pumping stations and/or storage tanks to account for pluvial drainage routes being cut off from the river. To account for the associated pluvial risk flap valves at storm drainage network outlets to the River Poddle are required. A revision to the maintenance plan and fitting culvert inlet screens are required. At the downstream end of the Poddle where the river is fully culverted a food risk is present from manholes surcharging. Up to 20 manholes have been identified as surcharging, sealing these manholes would prevent the flood risk from this source. To account for the potential flood risk resulting from blocked culverts at Harolds Cross, Mount Argus, Sundrive Road and Poddle Park additional and heightened flood walls are required totalling over 1.5km. Option 2 would consist of:

- Upstream Storage 280m of sheet piled core earth embankment averaging 2m in height and overflow weir around Tymon Park ponds.
- Hard defences 3420m of retaining wall and 180m of earth embankment.
- Sealing manholes manholes to be sealed along main Poddle culvert line at Dolphins Barn area and Poddle Park area.
- Culvert inlet screens
- Flap Valves
- Maintenance plan
- · Review of emergency response plan

#### 8.6.2 Option 3 - Hard defences, sealing manholes and flow diversion.

A suitable diversion route has been identified from the Poddle to the Dodder along Tymon Park running south of the M50. In order to be effective the flow needs to be reduced to the equivalent of the The diversion route is approximately 1km and falls 10m discharging 50%AEP flood event. downstream of the weir at Mount Carmel Park. A 1.5 diameter pipe would be required to convey flood water. Flow diversion will reduce the flood risk significantly but not entirely during the design event and therefore this measure will need to be used along with hard defences which would consist of flood walls and earth embankments located where the river banks are low relative to water level. Approximately 1.2km of downstream flood defence would be required with a flow diversion measure. Ancillary works will be required with hard defences such as pumping stations and/or storage tanks to account for pluvial drainage routes being cut off from the river. To account for the associated pluvial risk flap valves at storm drainage network outlets to the River Poddle are required. A revision to the maintenance plan and fitting culvert inlet screens are required. At the downstream end of the Poddle where the river is fully culverted a food risk is present from manholes surcharging. Up to 20 manholes have been identified as surcharging, sealing these manholes would prevent the flood risk from this source. To account for the potential flood risk resulting from blocked culverts at Harolds Cross, Mount Argus, Sundrive Road and Poddle Park additional and heightened flood walls are required totalling over 1.5km.

As this option transfers flow to another catchment (Dodder River), an estimate of €1M construction cost has been included to allow for works in the receiving watercourse. The costing is high level as until a detailed study is carried out it is not clear how the properties would be protected (as a group or individually) also as the increase in water level is small it may be that some properties identified will have suitably raised FFL so as to not require protection and others may have lower FFL than the assumed 300mm above ground level and so will require a higher level of flood defence. The assumption of a €1M construction cost would require reassessment during further scheme refinement, by modelling any impacts on Dodder River flood risks and identifying mitigation measures and associated costs, which is currently being considered.

Option 3 would consist of:

- Flow diversion 1.5m dia culvert 1070m in length. The culvert route will follow adjacent to the M50 in Tymon Park, past the national basketball arena and discharge to the Dodder immediately downstream of the weir near Mount Carmel Park.
- Hard defences 2800m of retaining wall and 145m of earth embankment.
- Sealing manholes manholes to be sealed along main Poddle culvert line at Dolphins Barn area and Poddle Park area.
- Culvert inlet screens
- Flap Valves
- Maintenance plan
- Review of emergency response plan

#### 8.6.3 Future Flood Risk

Part of the objective of the CFRAM studies is to consider the management of potential future flood risk. This was carried out in part through the MCA of potential FRM options which assesses the options adaptability or provision of protection up to the mid range future scenario (MRFS) and the high end future scenario (HEFS).

The MRFS represents the likely future scenario based on the wide range of predictions available and with allowances for increased flow, sea level rise, etc within the bounds of widely accepted projections. The HEFS represents a more extreme potential future scenario, but one that is nonetheless not significantly outside the range of accepted predictions available, and with allowances for increased flow, sea level rise, etc at the upper bounds of widely accepted projections.

Additional hydraulic model runs were carried out to represent the MRFS and HEFS in order to assess the potential impact to the proposed FRM options. The impact is summarised in tables 8.5 & 8.6 below.

Table 8.5 - Impact of future scenarios to Option 2

| Option 2 - Hard defences and Upstream Storage             |  |                                      |   |                          |                                |
|---|--|--------------------------------------|---|--------------------------|--------------------------------|
|   | Original<br>Water<br>Elevation<br>(m OD) | MRFS<br>Water<br>Elevation<br>(m OD) | MRFS<br>increased<br>water level<br>(m) | HEFS water elevation (m) | HEFS increased water level (m) |
| Area of minimum increase in water level (Wellington Lane) | 55.03                                    | 55.04                                | 0.01                                    | 55.04                    | 0.01                           |
| Area of maximum increase in water level (Poddle Park)     | 43.5                                     | 43.94                                | 0.44                                    | 44.18                    | 0.68                           |

Table 8.6 - Impact of future scenarios to Option 3

| Option 3 - Hard defences and Flow Diversion               |  |                                      |                                |                          |                                |
|---|--|--------------------------------------|--------------------------------|--------------------------|--------------------------------|
|   | Original<br>Water<br>Elevation<br>(m OD) | MRFS<br>Water<br>Elevation<br>(m OD) | MRFS increased water level (m) | HEFS water elevation (m) | HEFS increased water level (m) |
| Area of minimum increase in water level (Wellington Lane) | 55.03                                    | 55.04                                | 0.01                           | 55.04                    | 0.01                           |
| Area of maximum increase in water level (Poddle Park)     | 41.99                                    | 43.1                                 | 1.11                           | 43.21                    | 1.22                           |

The results from the hydraulic analysis showed that the increase in water level resulting from the MRFS and HEFS ranges from 0.01m - 0.68m with option 2 in place and 0.01m - 1.22m with option 3 in place. With the exception of Poddle Park which as a potential water level increase of up to 1.22m the potential increase in water levels along the remainder of the Poddle is up to 0.5m. While the proposed wall and embankment heights are suitable for the present day 1%AEP flood event it is anticipated that upgrading and modification will be required in the future to accommodate the MRFS and possibly the HEFS. The design of the walls and embankments should therefore allow for expansion in length and height. The ability of each option to accommodate this is reflected in the MCA scoring as shown in appendix B.

# 9 SUMMARY OF PREFERRED FRM OPTIONS FOR THE RIVER PODDLE

Options 2 and 3 (hard defences with storage or diversion respectively) are both viable, and have positive economic benefit-cost ratios. While the economic benefit-cost ratio for option 3 is slightly higher, option 2 has a better overall net benefit / cost ratio (i.e., provides greater benefits across all criteria of people, the environment, cultural heritage and the economy per euro spent). Option 2 is also the preferred option of the local community that is concerned about the possible diversion of flood flow from the Poddle into the Dodder and any resultant increase in flood risk along the River Dodder; a river already subject to significant flood risk.

The following FRM methods are therefore proposed for the River Poddle.

- Hard defences (flood walls and embankments) with flood storage (see appendix A & D)
- Sealing manholes (see appendix A & D)
- Culvert inlet screens (see sections 8.2 & 8.3)
- Flap Valves (see section 8.5)
- Maintenance plan (see section 8.3)
- Review of emergency response plan (see section 8.6)

Table 9.1 - Updated Preferred FRM option results for the River Poddle

| Option                           | 1   | 2  | 3  |  |
|----------------------------------|---|--|--|--|
|                                  | Hard defences and sealing manholes        | Hard defences, sealing manholes and upstream storage | Hard defences, sealing manholes and flow diversion |  |
| Benefit                          |   | €39,428,786  | €39,428,786  |  |
| Project whole life cost          |   | €19,148,216  | €17,193,373  |  |
| Multi Criteria Analysis<br>Score | Option dropped after consultation process | 2640   | 1925   |  |
| Benefit Cost Ratio               | р   | 2.06   | 2.29   |  |
| Overall Net<br>Benefit/Cost (€m) |   | 138  | 112  |  |

In addition the following FRM methods will be considered at UoM scale (Liffey and Dublin Bay) and Sub-Catchment scale (Liffey):

- Planning and development control
- Building Regulations
- Catchment wide SuDS
- · Land use management
- Strategic development management
- Flood warning/forecasting

While option 2 is preferred at this stage of analysis, more detailed analysis, design and costing is required before a Scheme can be brought forward for formal approval (be it through Part VIII or Public Exhibition under the Arterial Drainage Act, 1945/95). At this next stage of assessment, alternatives to the preferred option (option 2) do need to be considered, and this should include more detailed analysis of option 3.

#### 9.1 RECOMMENDATIONS

The overall recommendations resulting from this study is:

• to pursue option 2 as the preferred option, but noting that option 3 is also viable and should be considered under any further analysis

to examine other measures at UoM scale

In order to progress the preferred options to detailed design, it is important to record the following limitations, assumptions and recommendations for detailed design

#### 9.1.1 Hydraulics

- The Poddle Model was carried out using an integrated catchment model including the main storm sewer network. It does not include all gullies but has the potential to be used in a more detailed study.
- In relation to option 2 (Tymon Park flood storage) the flow reduction along the River Poddle is controlled by the storage capacity at Tymon Park and the outlet control. This was dictated by existing topography in the park. However it is noted that an increased reduction in flow will result in a decrease in the height and length of the flood walls and embankments required. This may reduce the amount of walls required to mitigate the culvert blockage risk significantly. As part of the detailed study it is recommended that the potential to increase storage from the existing proposal at Tymon Park be assessed.
- A wall at Poddle Park was included following the consultation process and the flood hazard maps updated accordingly. This wall was not included in the optioneering process but will be required to be accounted for in the detail design stage.

#### 9.1.2 Optioneering

- The analysis presented in this report is based on the baseline results of the hydraulic modelling that had been conducted by October 2013. Subsequently, a further technical review was carried out, which resulted in modifications being made to the model such as, for example, the inclusion of Poddle Park Wall as a hydraulically significant structure. These modifications resulted in changes in the flood extents that are not represented in this document. However, RPS are confident that these hydraulic refinements will not reduce the damage values detailed in this report such that the preferred option becomes economically unviable, nor change the preferential order of the options.
- Property classification included type only. There is scope to refine the damage assessment
  by including property age and social class as per MCM guidance recommendations. A
  distributional impact analysis will be required and weighted factor applied to social class
  groups as per MCM guidance recommendations (see section 5.3).
- A review of the conversion rates (2010 values to present day and Pound sterling to Euro) may be required when the detailed assessment is due to be carried out (see section 5.6).
- 10.7% of residential damages was assumed to account for emergency service costs (see section 5.7).
- A review of the housing capping value may be required when the detailed assessment is due to be carried out (see section 5.9).
- It is recommended that pluvial flood risk be considered along with the fluvial flood risk due to
  their integrated nature. This would require an additional pluvial flood risk and management
  study. Part of this study should include the provision of increased capacity to the storm
  drainage network.
- A more detailed costing of flood measures is recommended. A survey along the line of the flood walls and embankments will provide details to cost the defences more accurately. The survey can also be used to provide information in order to answer some unknowns which are accounted for in the optimism bias and contingencies, such as land acquisition, site conditions, etc (see sections 7.1.5 & 7.2.1).

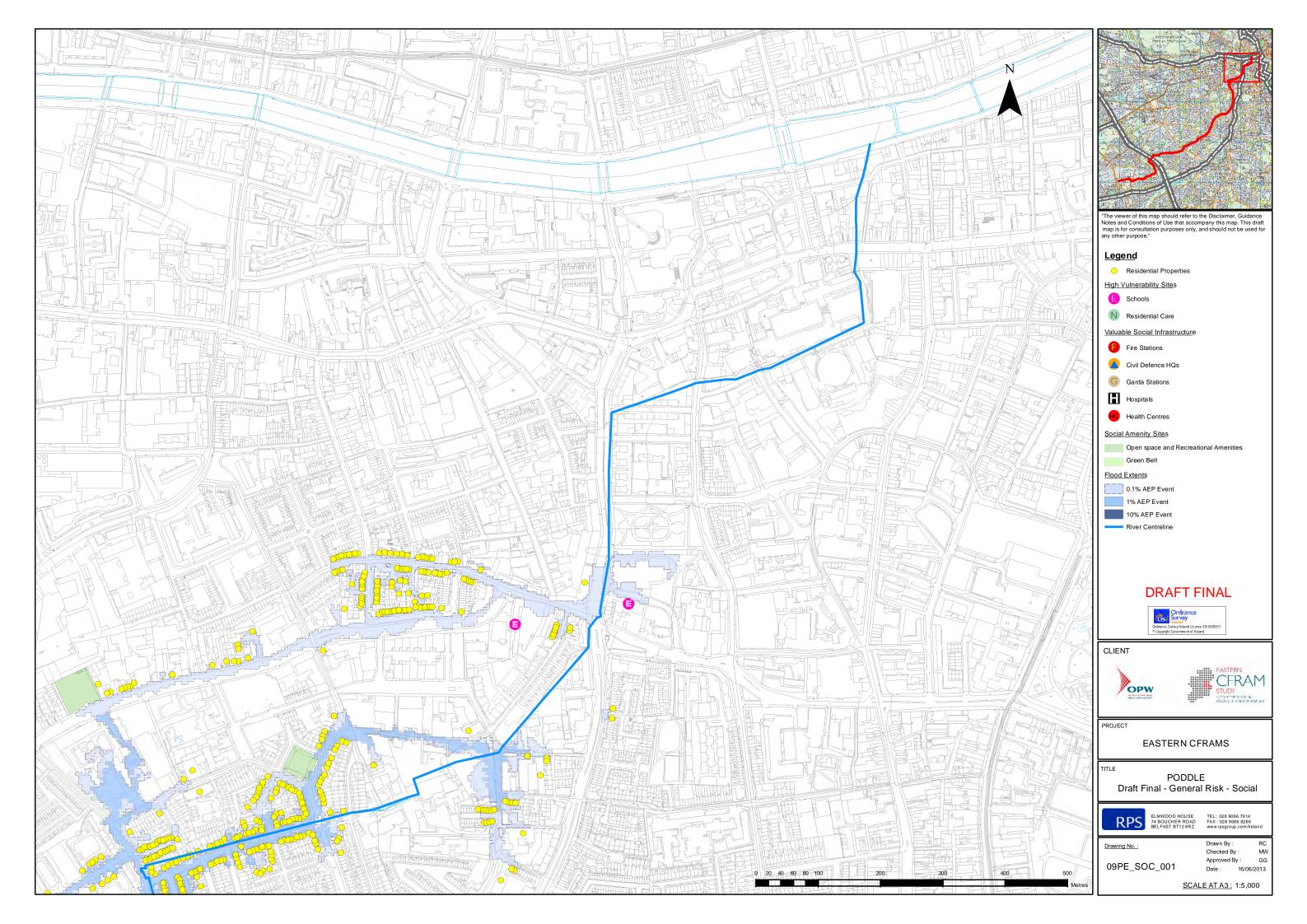
Consider including Bancroft Park in the storage option to increase storage capacity with the
possibility of creating a series of integrated constructed wetland areas by widening the River
Poddle. This could be extended into Tymon Park also and continued into Glendown and
Wainsfort open spaces also. These measures should also be considered in terms of their
social and environmental benefits such as the treatment of very polluted waters, enhancing
the amenity value of the parks and linking with the construction of combined cycle and walking
paths and new trails in order to meet with the objectives of the Department of Transport, Sport
and Tourism.

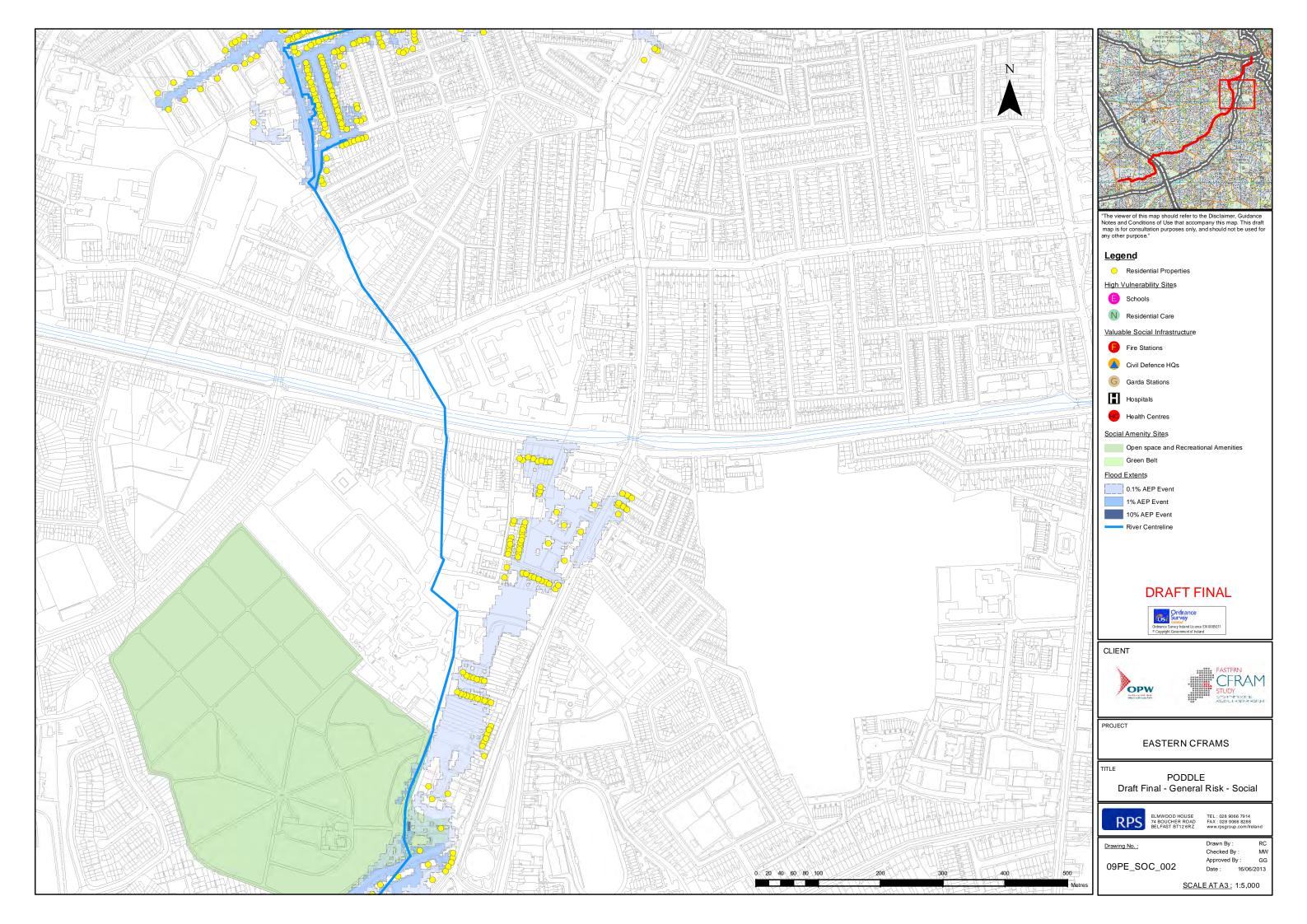
- Given the nature of the measures proposed and the context of the receiving environment, it is strongly recommended that the Part VIII route is followed and that an Environmental Impact Report is completed to support the Part VIII planning application. This should include an assessment of the potential impacts of the project on flora and fauna, cultural heritage and landscape as a minimum and should be carried out by suitable qualified specialists. The report should also contextualize the works within the Eastern CFRAM Study and where possible use similar and compatible assessment criteria to ensure there is no potential for conflict with the Eastern CFRAM Study process. The Eastern CFRAM Study will address these advanced works in the context of baseline conditions which will reflect the flood relief works for this catchment. In this way the cumulative impacts associated with the wider CFRAM Study will be captured more appropriately at the CFRAM Study level of assessment.
- All walls and embankments should be designed to accommodate increasing its height and length in the future.

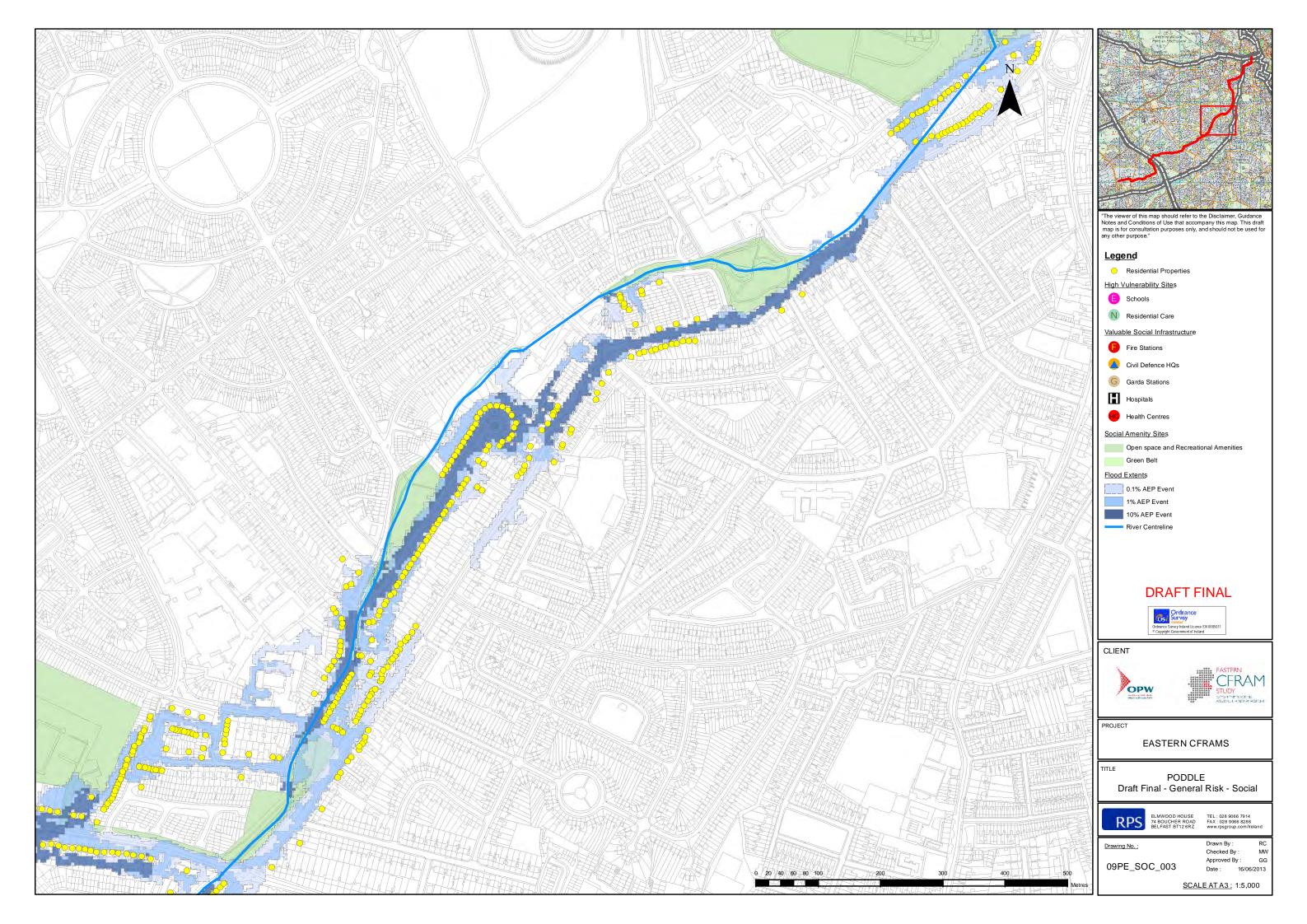
#### 9.1.3 Option 3

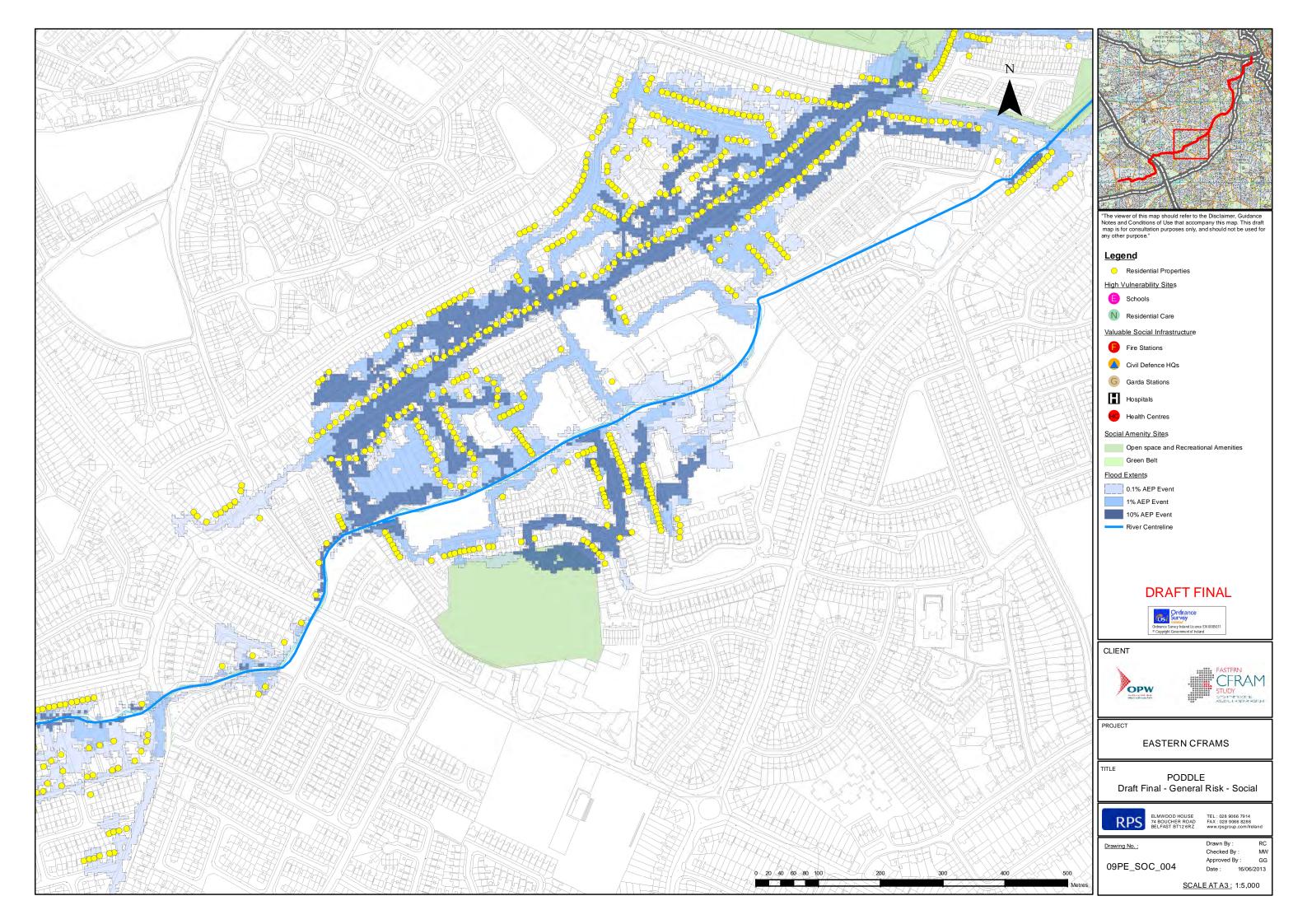
- In choosing the most appropriate option the increase in flood risk to the Dodder area would need to be examined and how to address the risk identified.
- Consider an open channel as part of option 3 (diversion to the Dodder) and integrating it as a park feature to protect biodiversity.
- If option 3 (diversion to the Dodder) proceeds it is recommended that a property threshold survey be carried out on the additional properties identified as at risk (see section 8.4).
- Assess the impact to the National Recorded Monuments Firhouse Weir and City Watercourse
  due to their significant archaeological interest and route the diversion to avoid compromising
  existing structures and consider energy dissipation at the outlet if required.
- Consider the use of Dodder Valley Park and Bushey Park as storage areas to reduce the impact of the diversion from the Poddle.

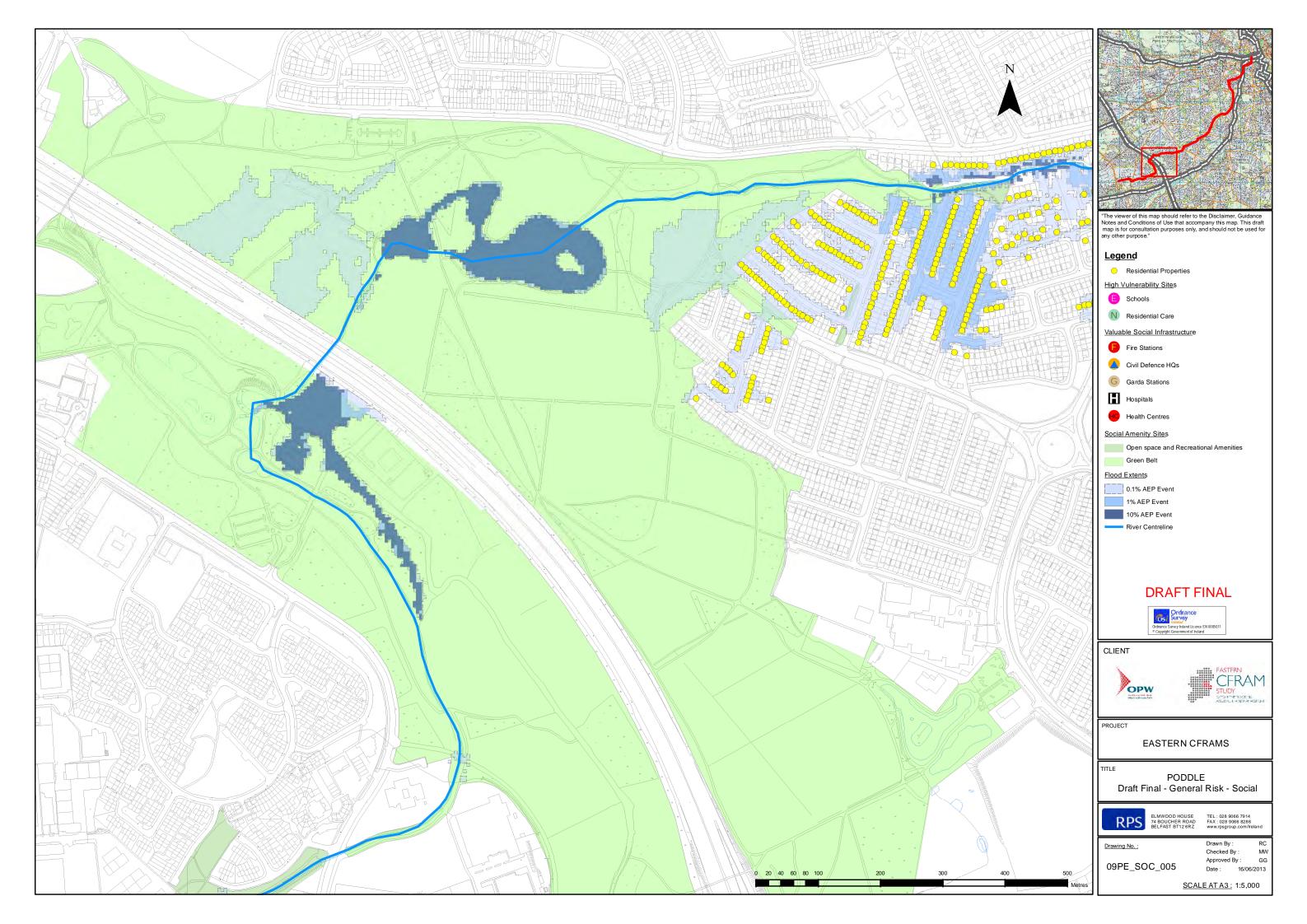
# Appendix A Flood Risk Maps

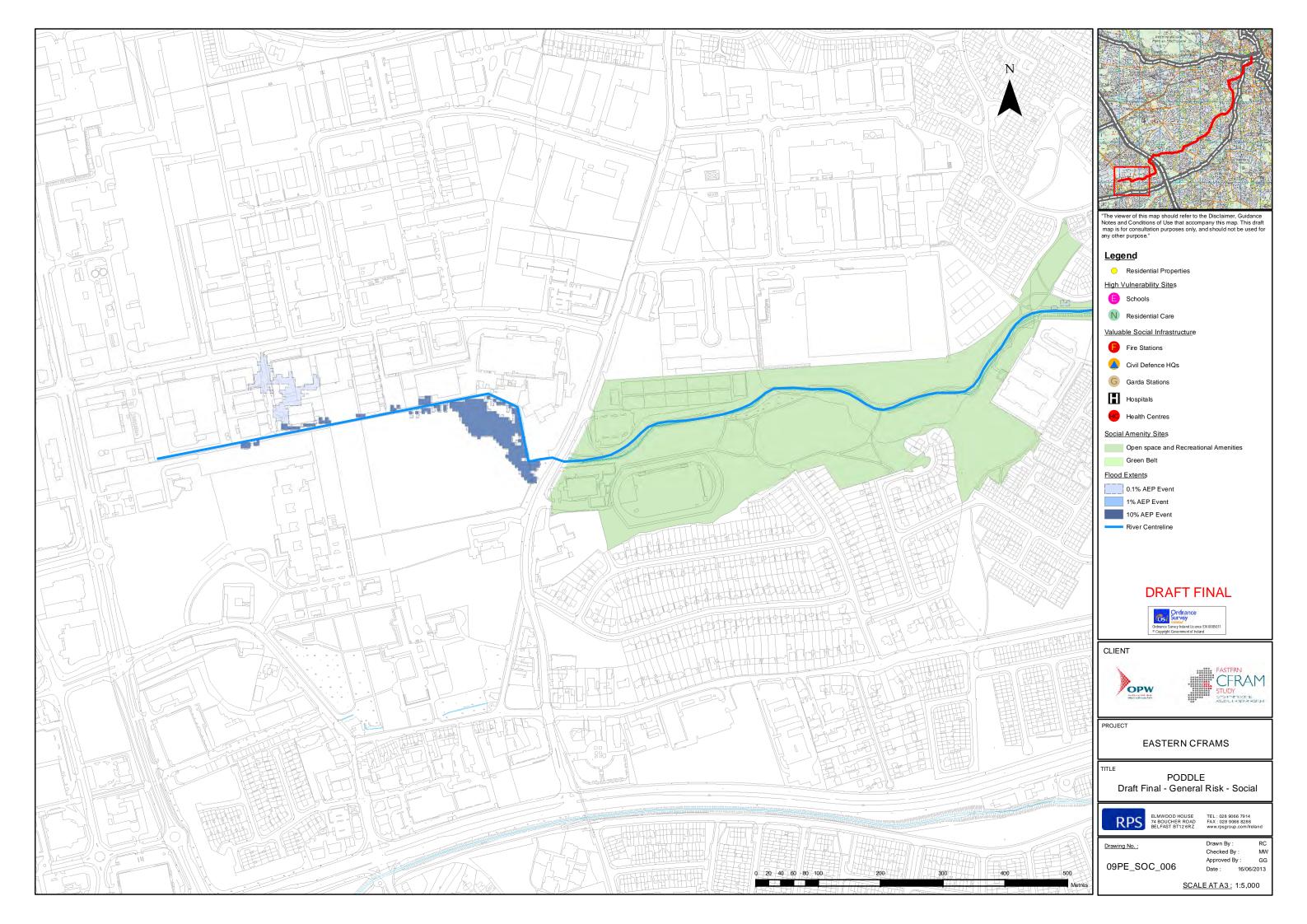


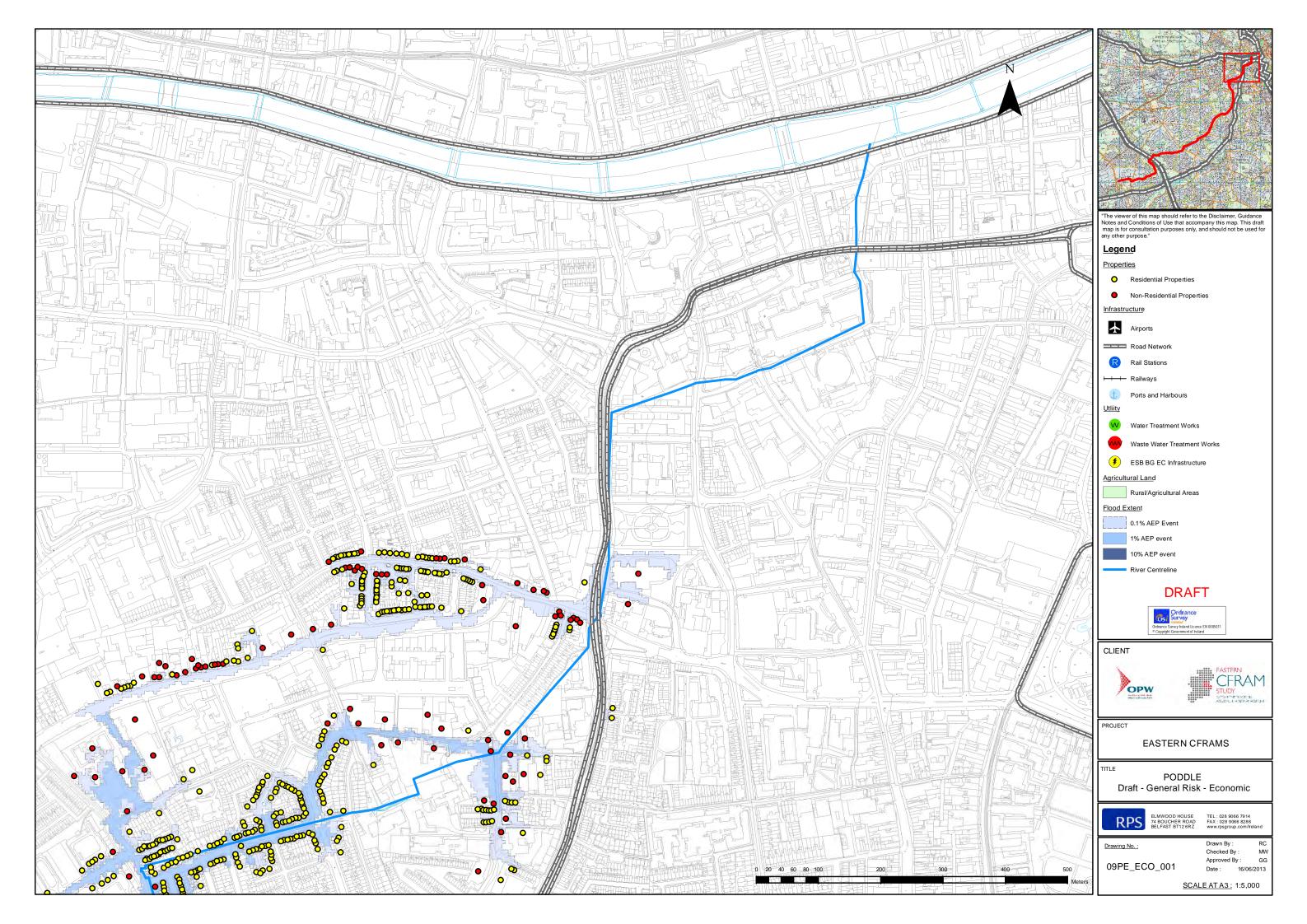


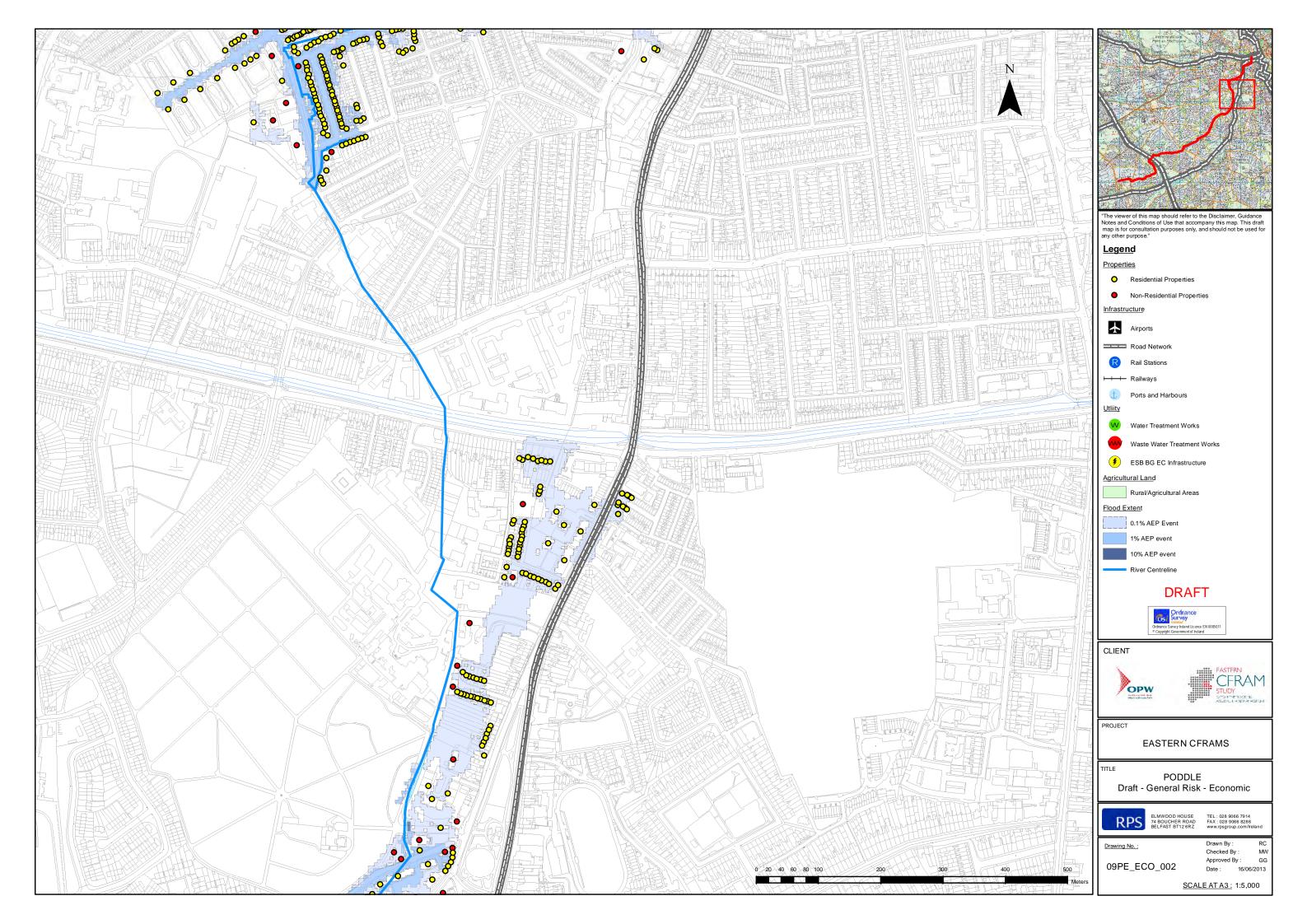


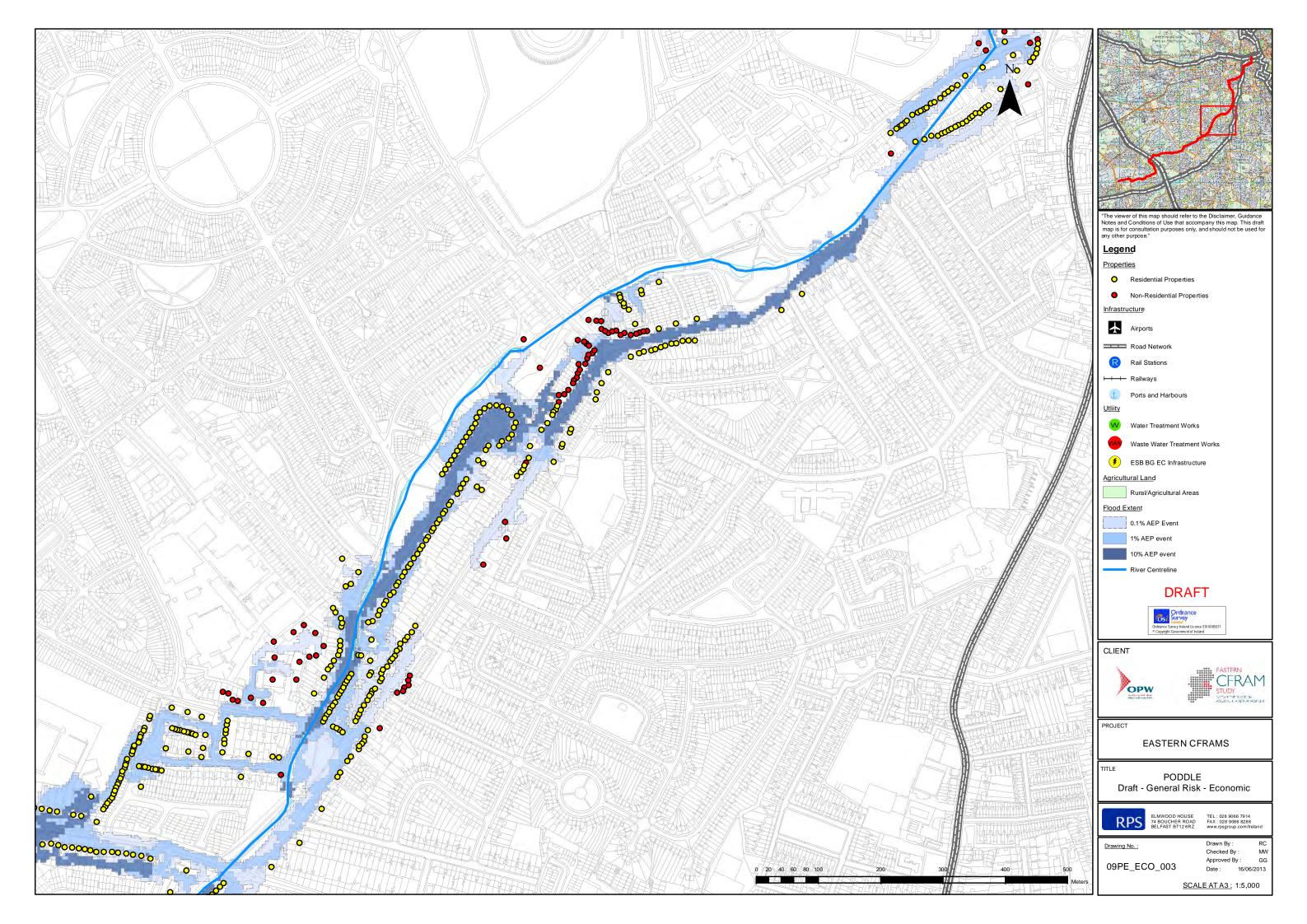


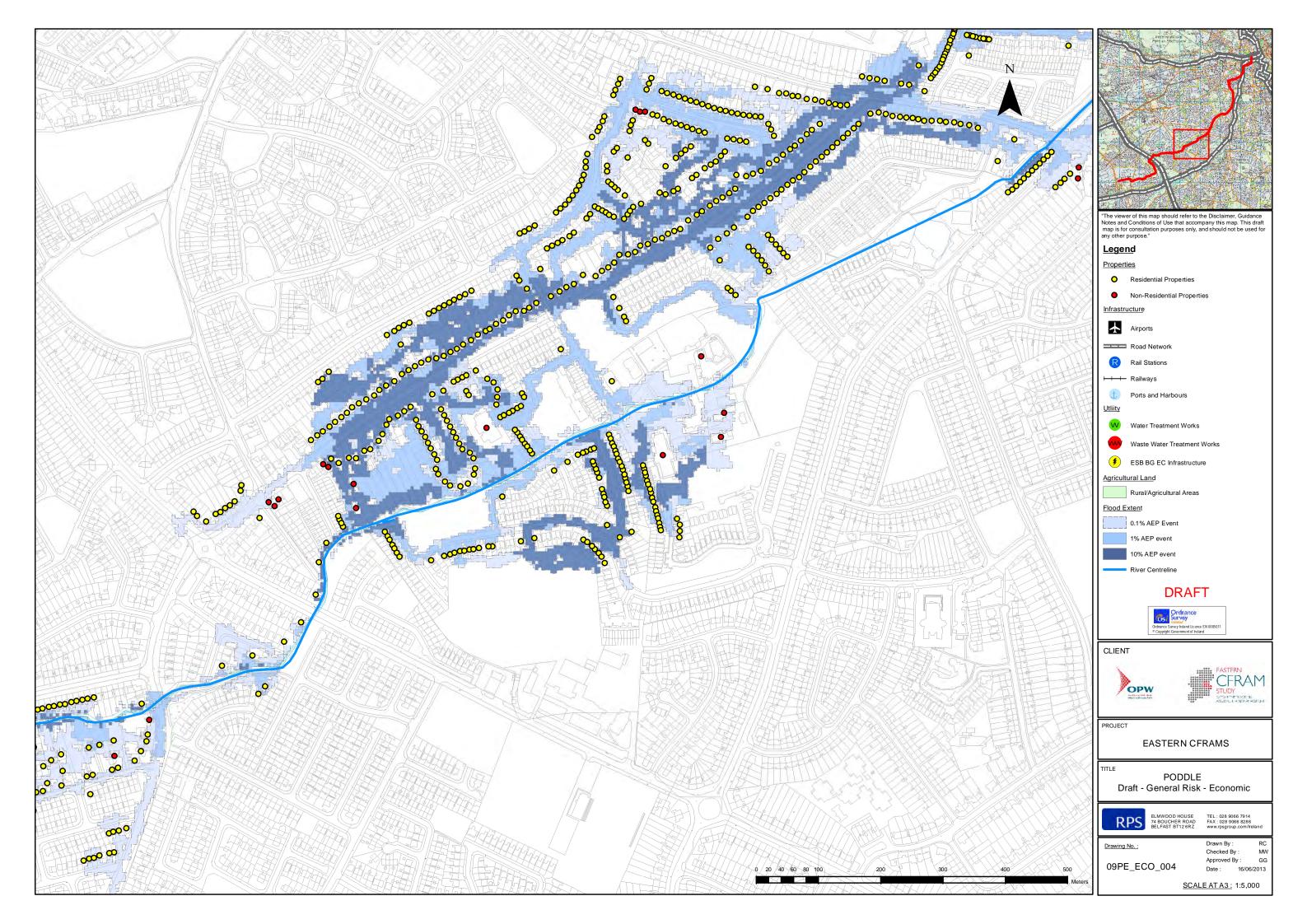


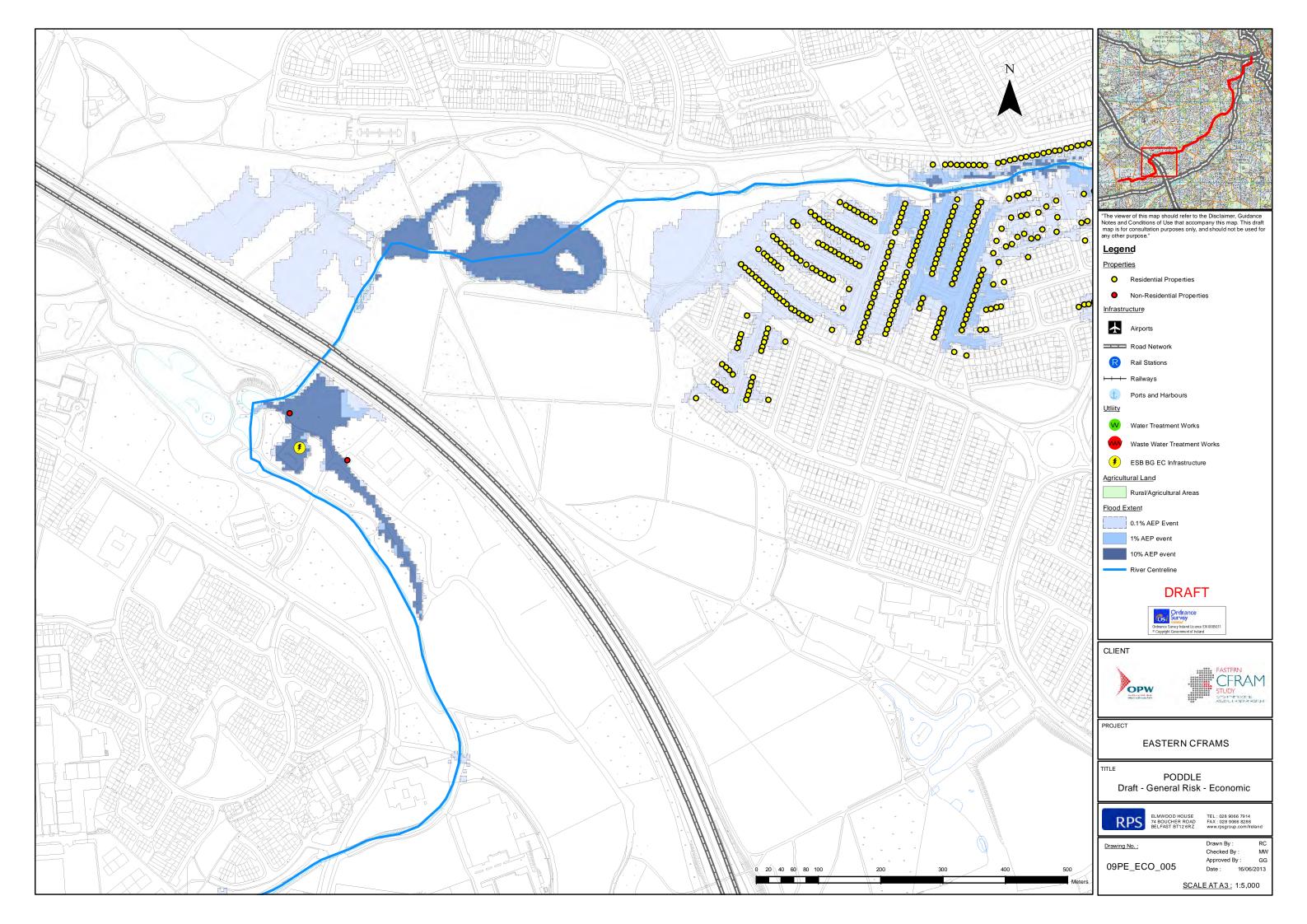


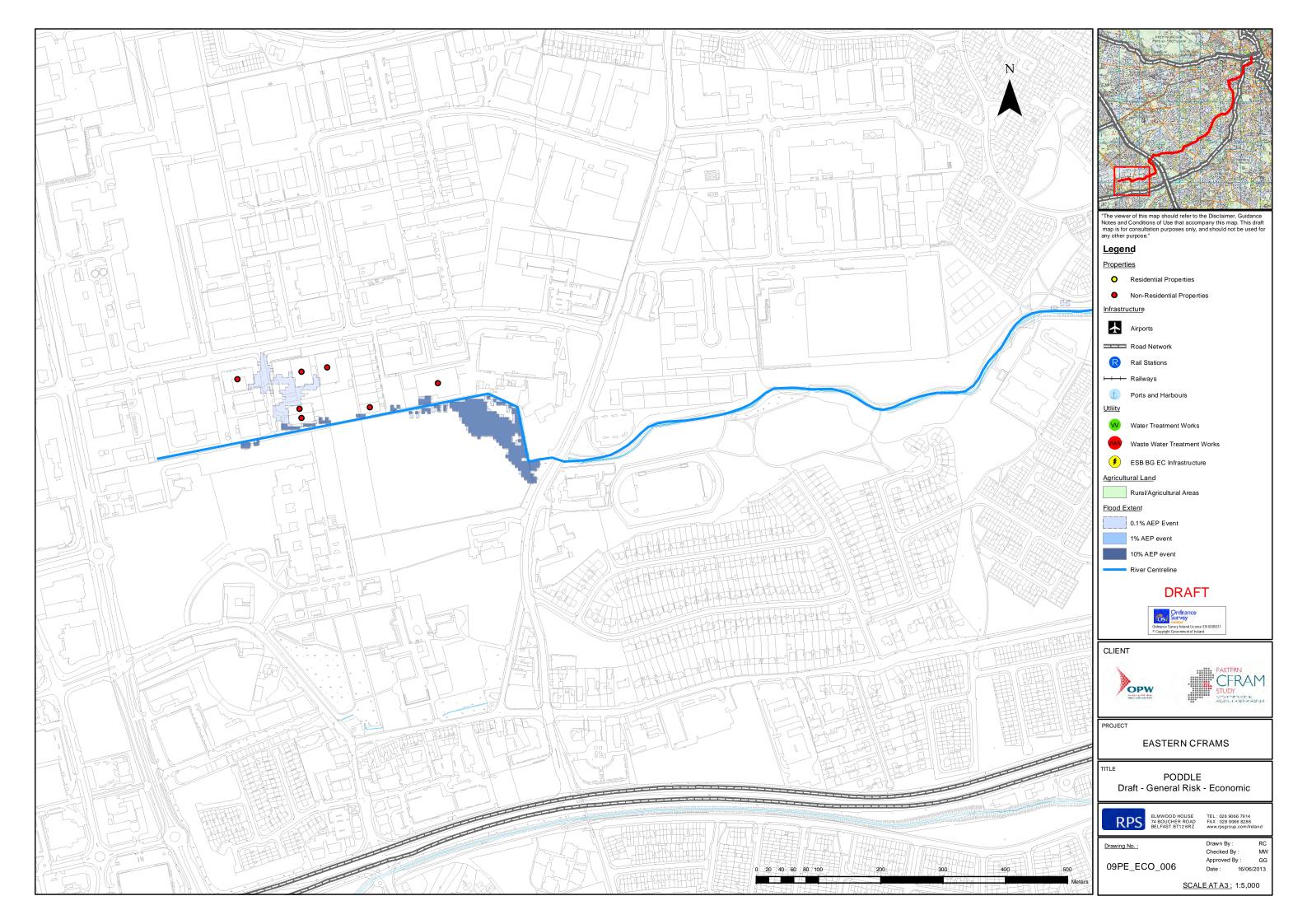


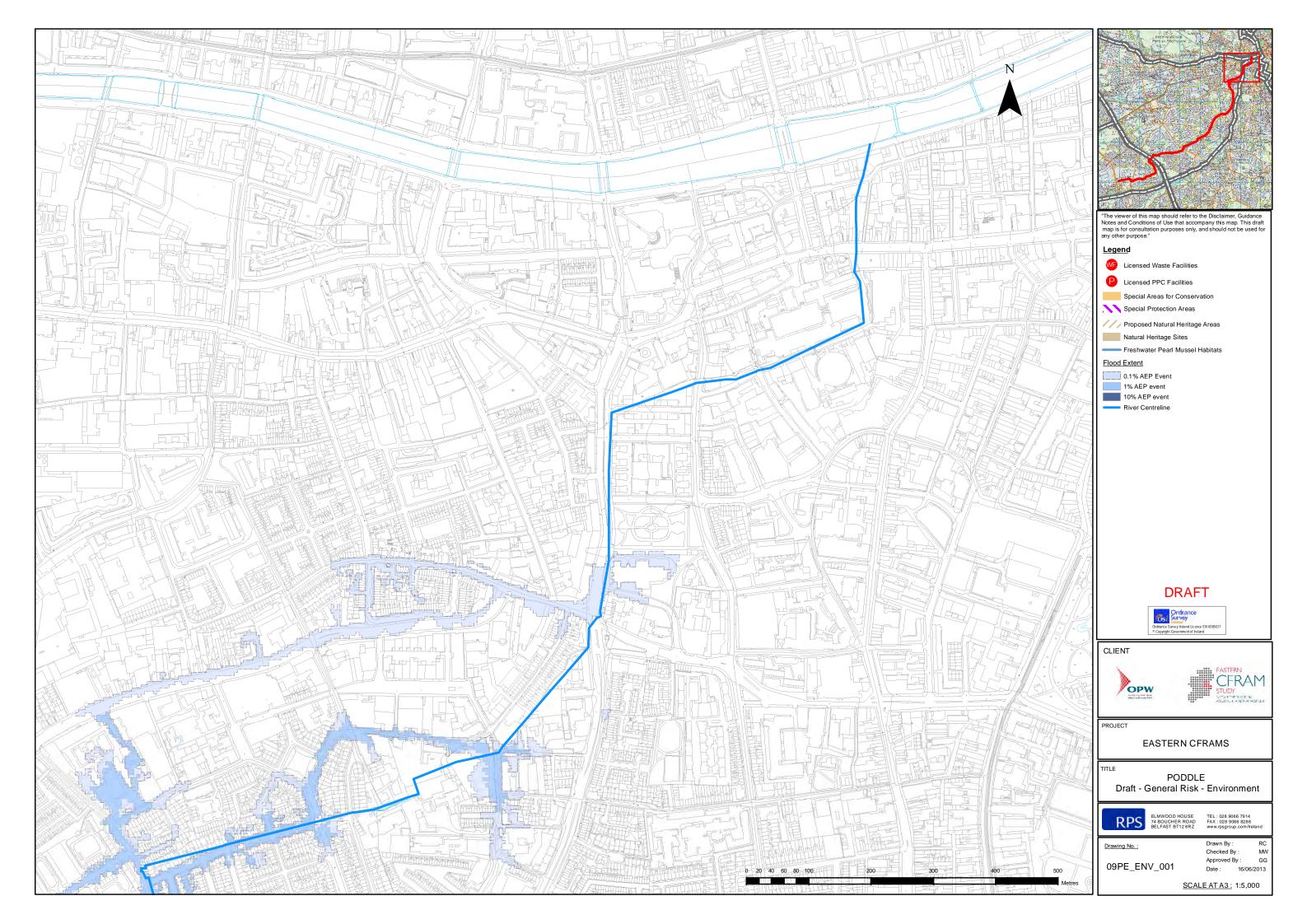


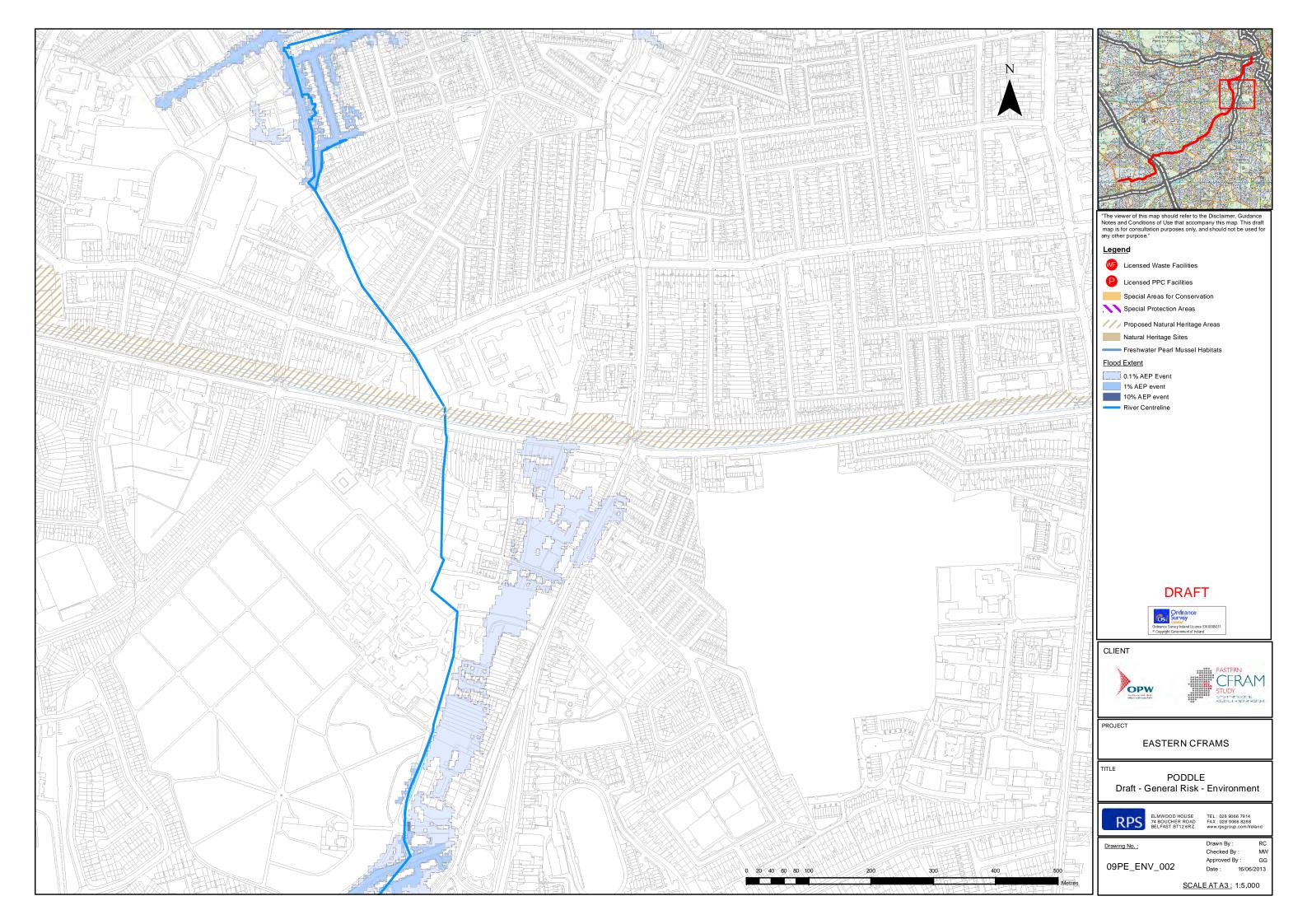


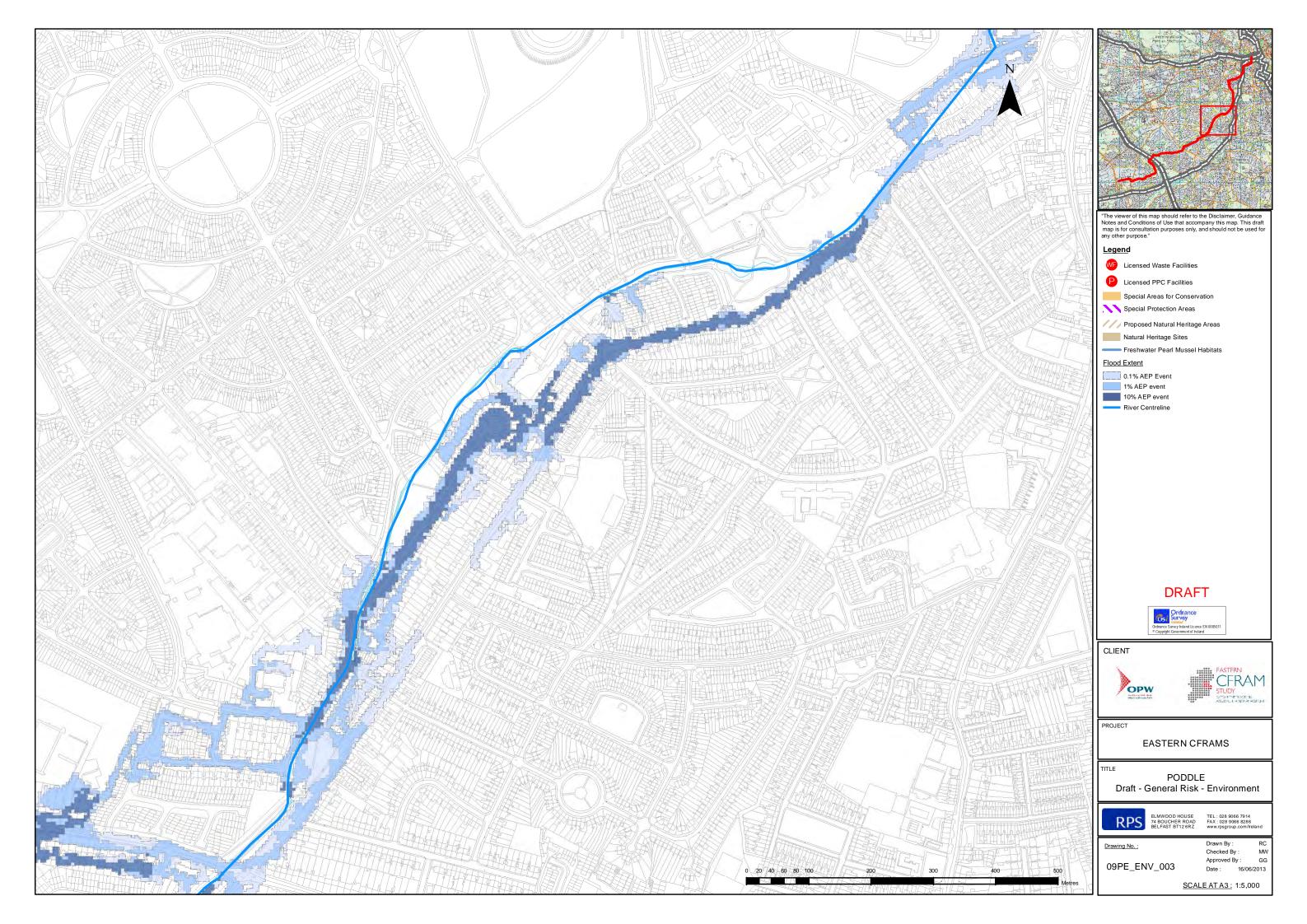


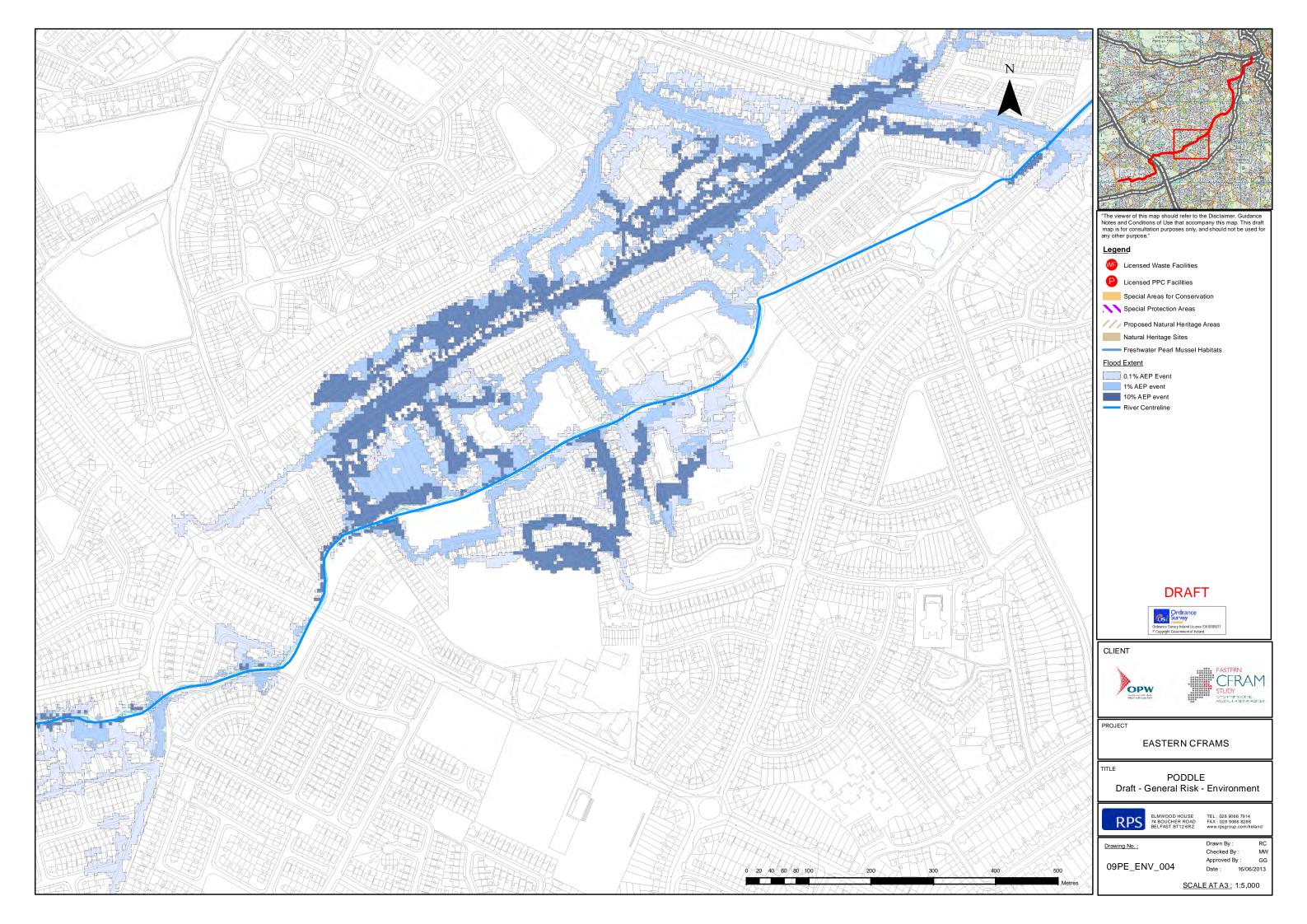


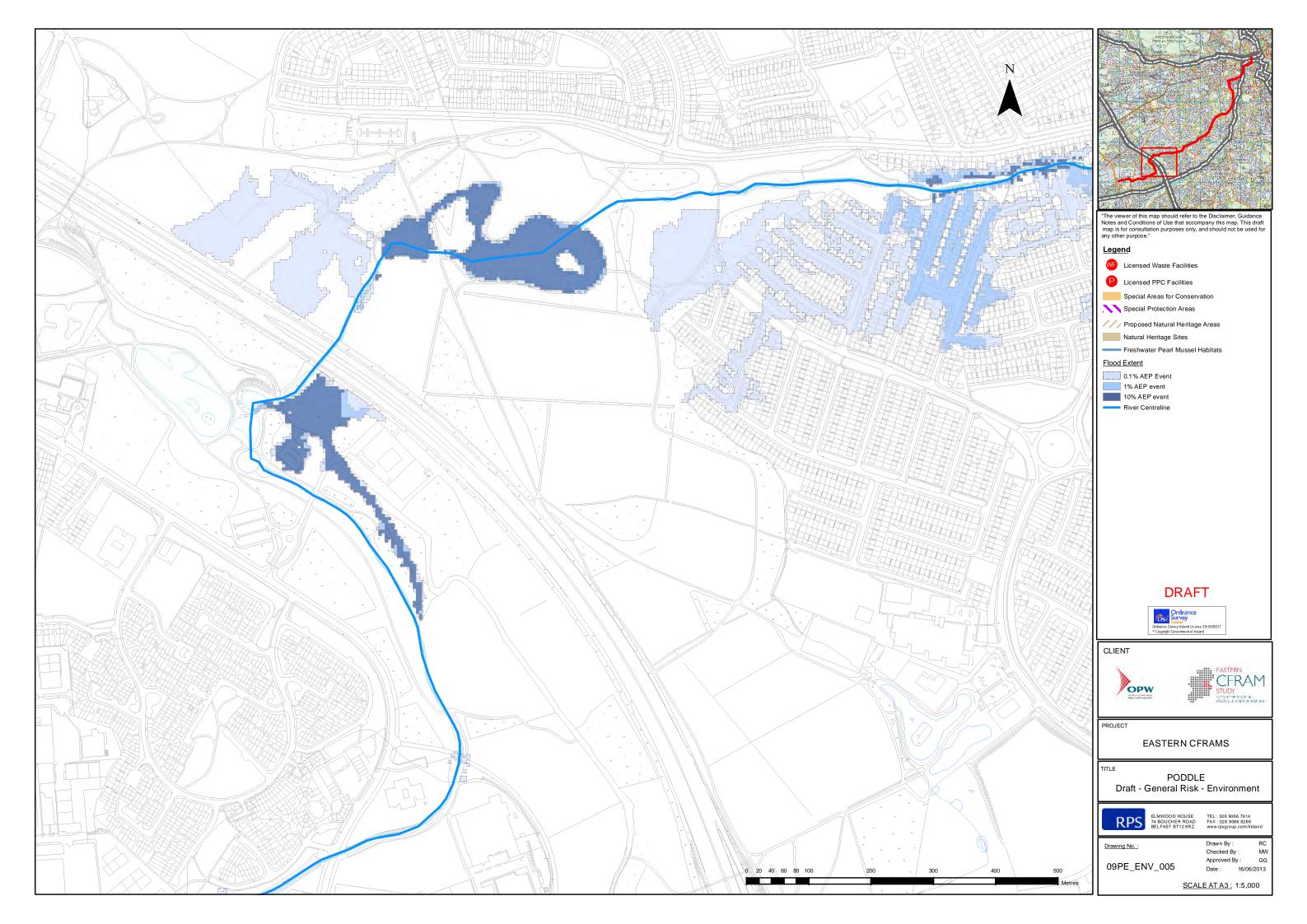


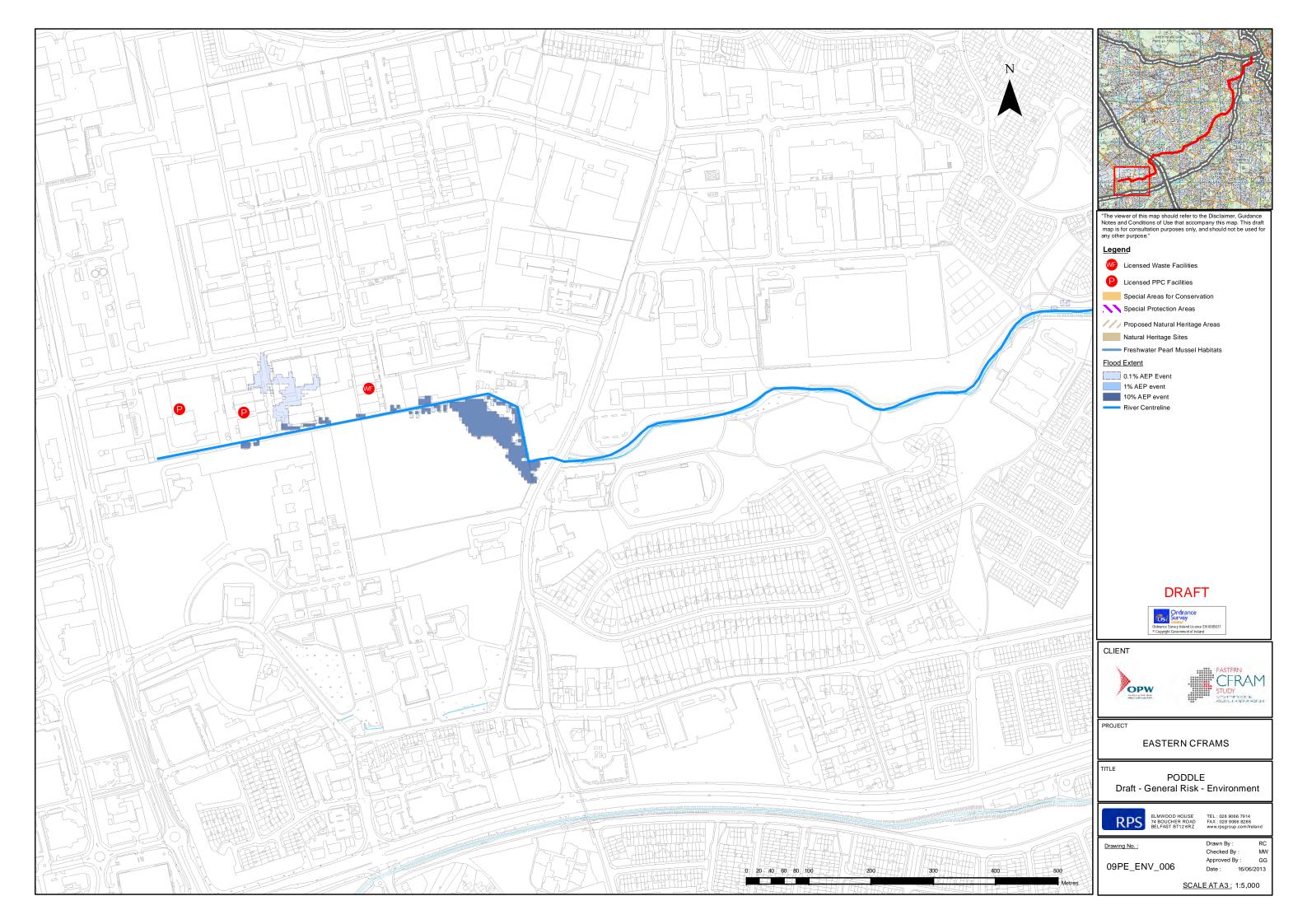


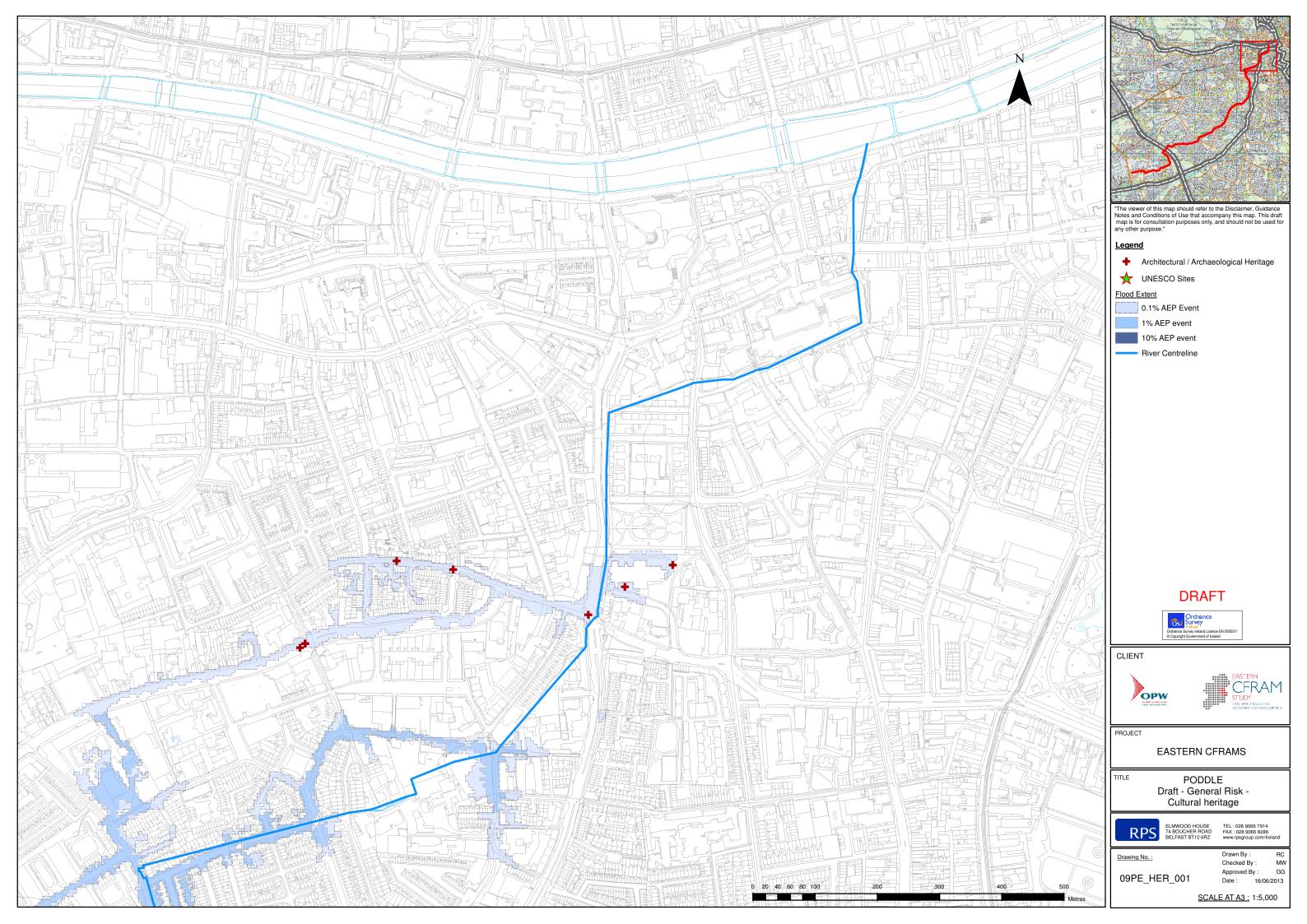


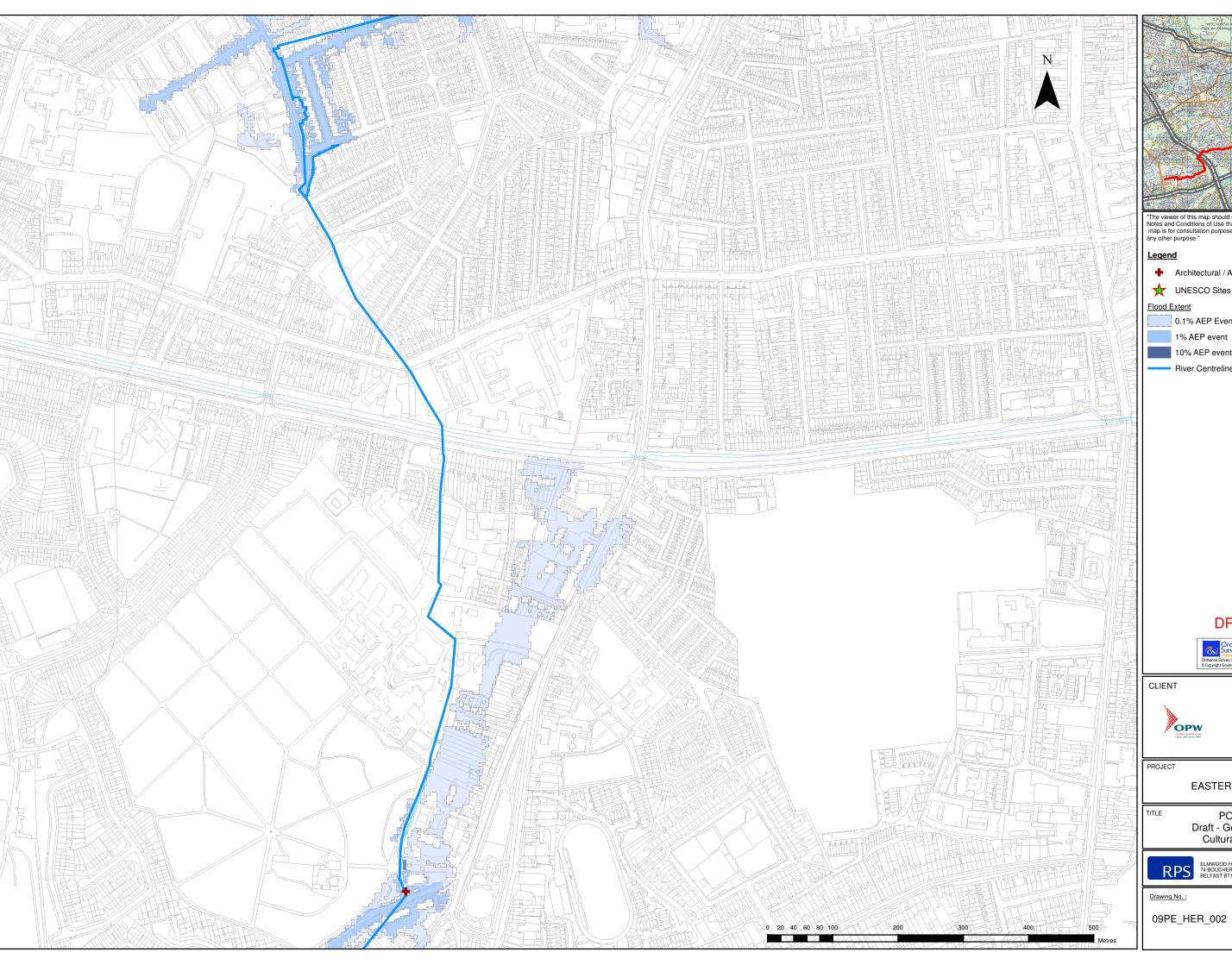














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+ Architectural / Archaeological Heritage



0.1% AEP Event

1% AEP event

10% AEP event

River Centreline

DRAFT



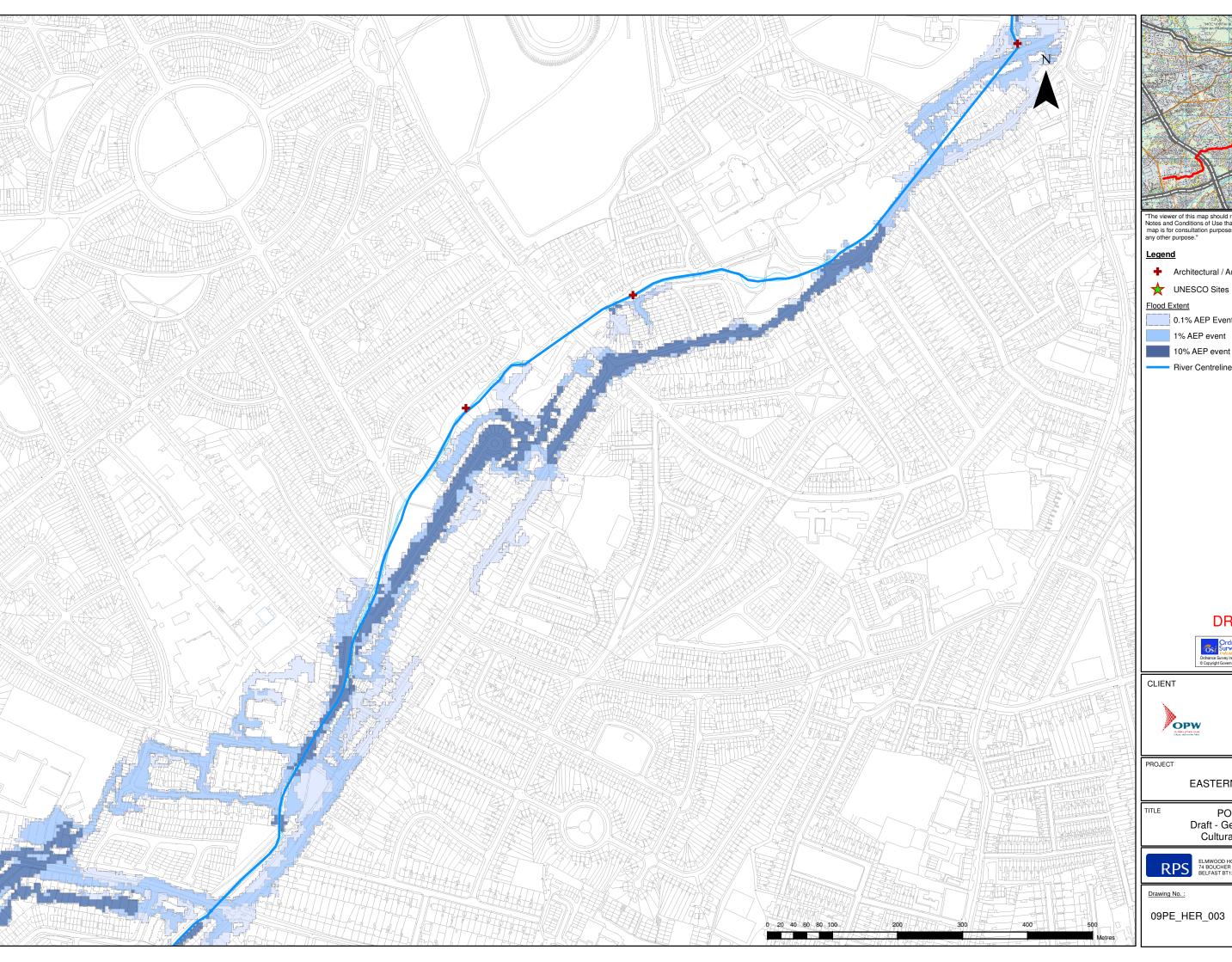


**EASTERN CFRAMS** 

PODDLE Draft - General Risk -Cultural heritage

Checked By : Approved By :

SCALE AT A3: 1:5,000





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+ Architectural / Archaeological Heritage

0.1% AEP Event

1% AEP event

10% AEP event

River Centreline

DRAFT





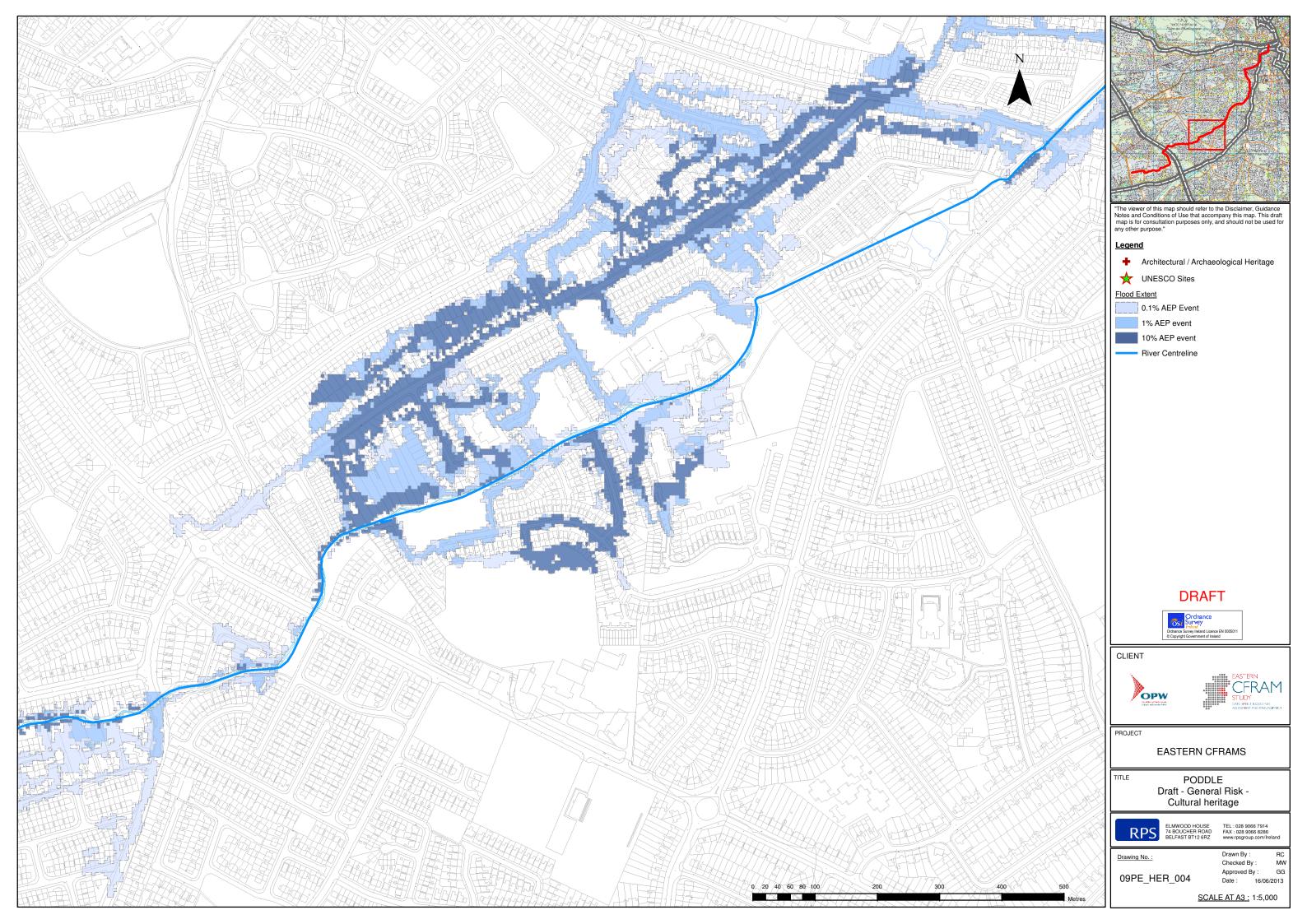
EASTERN CFRAMS

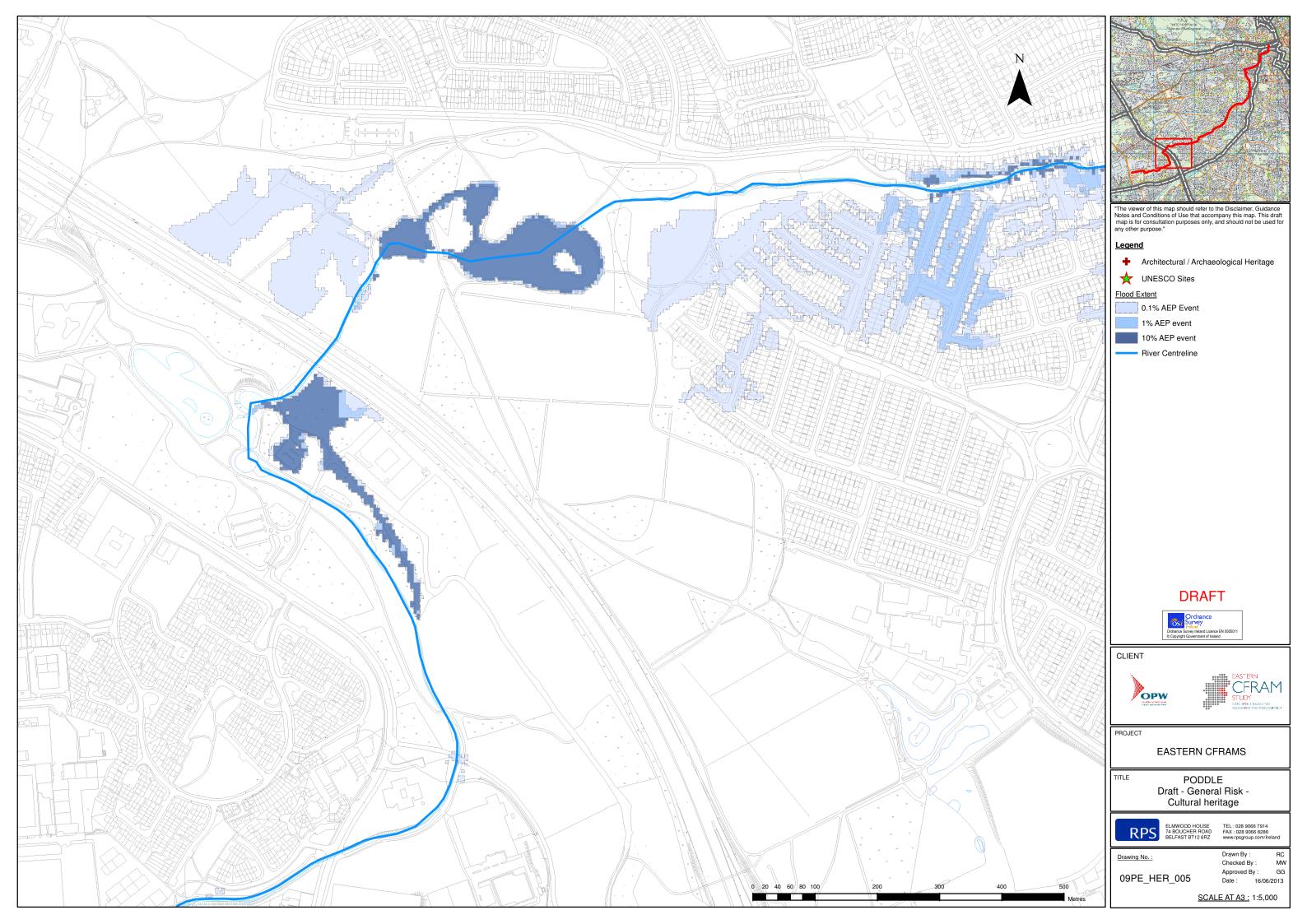
PODDLE Draft - General Risk -Cultural heritage

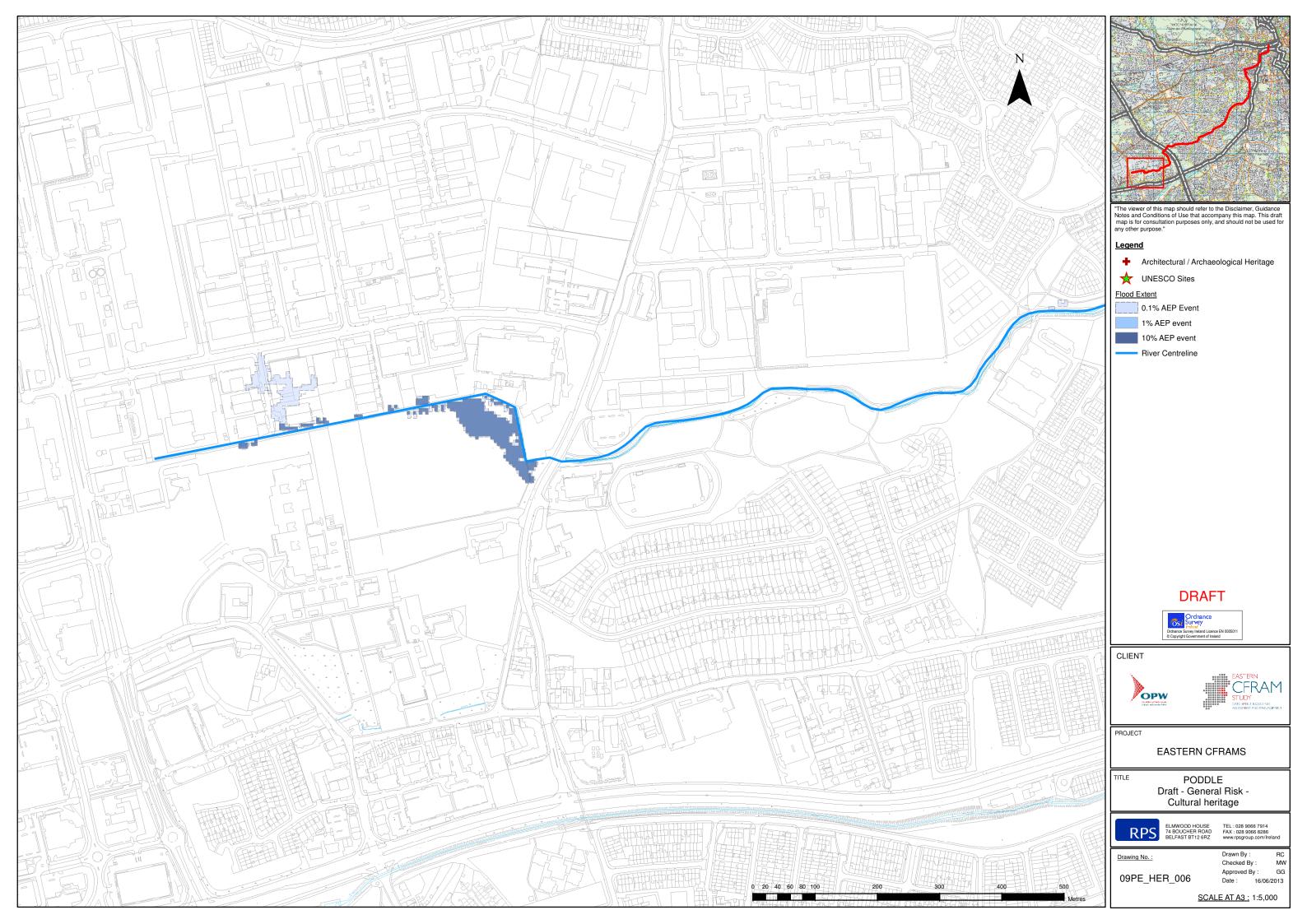
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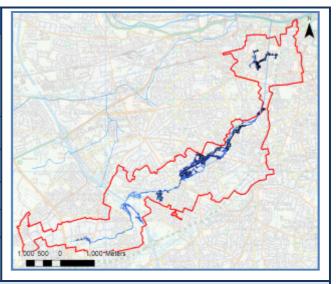


| Name   | Local Authority            | Unique ID | SSA | Status      | Date       |
|--------|----------------------------|-----------|-----|-------------|------------|
| Poddle | Dublin City & South Dublin | -         | HPW | Draft Final | 17/10/2013 |

| Flood | Risk | Receptor | summary |
|-------|------|----------|---------|
|       |      |          |         |

During a 1% AEP event (i.e. often referred to as 100 year flood) the following receptors are at risk on the Poddle:

| Poddie.                 |      |      |
|-------------------------|------|------|
| Receptor                | Item | Unit |
| Residential<br>Property | 837  | No.  |
| Commercial<br>Property  | 85   | No.  |
| SMR                     | 1    | No.  |
| RMP                     | 1    | No.  |
| pNHA                    | 1    | No.  |



- Residential areas with small commercial properties are mainly at risk from overland flooding and surcharging culvert networks originating from the Poddle River.
- There is 1 SMR (Sites and Monument Record) within the 1% AEP flood extent.
- There are amenity areas with development plan amenity objectives within the 1% AEP flood extent.
- A stretch of the Poddle River is listed in the Record of Monuments and Places (RMP) under the National Monuments Act. The catchment is considered of high archaeological potential.
- The pNHA within the 1% AEP flood extent is the Grand Canal.

#### 1. Short listing of measures - applicability review

| Measure                             | Review comment   | Applicable? |
|-------------------------------------|--|-------------|
| Do Nothing                          | No maintenance. Consider further                           | ✓           |
| Maintain Existing Regime            | Baseline Condition. Consider further                       | ✓           |
| Do Minimum                          | Consider further   | ✓           |
| Planning and development control    | To be considered at UoM and Sub-Catchment SSA              | ×           |
| Building regulations                | To be considered at UoM and Sub-Catchment SSA              | ×           |
| Catchment wide SuDS                 | To be considered at UoM and Sub-Catchment SSA              | ×           |
| Land use management                 | To be considered at UoM and Sub-Catchment SSA              | ×           |
| Strategic Development Management    | To be considered at UoM and Sub-Catchment SSA              | ×           |
| Maintenance programme               | Consider further   | ✓           |
| Upstream storage/storage            | Consider further   | ✓           |
| Tidal barrage/flap valve            | Consider further   | ✓           |
| Improvement of channel conveyance   | Consider further   | ✓           |
| Hard defences                       | Consider further   | ✓           |
| Relocation of properties            | Consider further   | ✓           |
| Culverting                          | Consider further   | ✓           |
| Diversion of flow                   | Consider further   | ✓           |
| Overland floodways                  | Consider further   | ✓           |
| Rehabilitation of existing defences | No existing defences requiring rehabilitation              | x           |
| Localised protection works          | Consider further   | ✓           |
| Flood warning/forecasting           | To be considered at UoM and Sub-Catchment SSA <sup>1</sup> | ×           |
| Public awareness campaign           | Consider further   | ✓           |
| Individual property protection      | Consider further   | ✓           |
| Sealing manholes                    | Consider further   | <b>√</b>    |

<sup>&</sup>lt;sup>1</sup> In order to provide an effective flood warning and forecast system it would require monitoring that will benefit the entire Liffey UoM and therefore should be looked at that SSA. See Liffey Flood Controls and Flood Forecasting System Option Report for more details.



| Measure                           | Review comment                                    | Feasible?  |
|-----------------------------------|---|------------|
| Do Nothing                        | FRM Method unacceptable                           | r easible: |
|                                   |   |            |
| Maintain Existing Regime          | FRM Method can continue through screening process | <b>V</b>   |
| Do Minimum                        | FRM Method unacceptable                           | X          |
| Maintenance programme             | Consider as a secondary FRM Method                | ×          |
| Upstream storage/storage          | FRM Method can continue through screening process | ✓          |
| Tidal barrage                     | Consider as a secondary FRM Method                | ×          |
| Improvement of channel conveyance | Consider as a secondary FRM Method                | ×          |
| Hard defences                     | FRM Method can continue through screening process | ✓          |
| Relocation of properties          | Consider as a secondary FRM Method                | ×          |
| Culverting                        | Consider as a secondary FRM Method                | ×          |
| Diversion of flow                 | FRM Method can continue through screening process | ✓          |
| Overland floodways                | Consider as a secondary FRM Method                | ×          |
| Localised protection works        | Consider as a secondary FRM Method                | ×          |
| Public awareness campaign         | Consider as a secondary FRM Method                | ×          |
| Individual property protection    | Consider as a secondary FRM Method                | ×          |
| Sealing manholes                  | FRM Method can continue through screening process | ✓          |

<sup>\*</sup> refer to section B1 for further details on review comments

#### 3.1 Environmental Review\*

| Measure                  | Review comment                                    | Continue? |
|--------------------------|---|-----------|
| Maintain Existing Regime | FRM Method can continue through screening process | ✓         |
| Upstream storage/storage | FRM Method can continue through screening process | ✓         |
| Hard defences            | FRM Method can continue through screening process | ✓         |
| Diversion of flow        | FRM Method can continue through screening process | √!        |
| Sealing manholes         | FRM Method can continue through screening process | ✓         |

<sup>\*</sup> refer to section B2 for further details on review comments with explantion marks

#### 3.2 Social/Cultural Review\*

| Measure                  | Review comment                                 | Continue? |
|--------------------------|--|-----------|
| Maintain Existing Regime | Measure can continue through screening process | ✓         |
| Upstream storage/storage | Measure can continue through screening process | ✓         |
| Hard defences            | Measure can continue through screening process | √!        |
| Diversion of flow        | Measure can continue through screening process | √!        |
| Sealing manholes         | Measure can continue through screening process | ✓         |

<sup>\*</sup> refer to section B2 for further details on review comments with explantion marks

#### 3.3 Economic Review

| Measure                  | Construction cost and comment                  | Continue? |
|--------------------------|--|-----------|
| Maintain Existing Regime | No construction cost associated with measure   | ✓         |
| Upstream storage/storage | Approx €2,257,500 - cost acceptable            | ✓         |
| Hard defences            | Approx €4,837,614 - cost acceptable            | ✓         |
| Diversion of flow        | Approx €2,015,000 - cost acceptable            | ✓         |
| Sealing manholes         | Minimal construction cost to implement measure | ✓         |



#### 4. List of FRM method combinations providing 1% AEP flood event standard of protection\*

| Ор | <b>Option</b>  |  |  |
|----|--|--|--|
| 1  | Hard defences and sealing manholes                   |  |  |
| 2  | Hard defences, sealing manholes and upstream storage |  |  |
| 3  | Hard defences, sealing manholes and flow diversion   |  |  |

refer to section B3 for details of option matrix

#### 5. Economic Review

| Option | Benefit     | Construction Cost | pBCR* | Acceptable? |
|--------|-------------|-------------------|-------|-------------|
| 1      | €17,838,862 | €5,353,504        | 3.33  | ✓           |
| 2      | €17,838,862 | €4,741,505        | 3.76  | ✓           |
| 3      | €17,838,862 | €3,750,443        | 4.76  | ✓           |

BCR is the ratio between the benefit and the construction cost

#### 6. Summary of MCA\*

| Option | Description  | Benefit     | Project whole life cost <sup>+</sup> | MCA score | BCR  | Overall Net<br>Benefit /Cost (€m) |
|--------|--|-------------|--------------------------------------|-----------|------|-----------------------------------|
| 1      | Hard defences and sealing manholes                   | €17,838,862 | €12,672,152                          | 2075      | 1.41 | 164                               |
| 2      | Hard defences, sealing manholes and upstream storage | €17,838,862 | €11,412,093                          | 2640      | 1.56 | 231                               |
| 3      | Hard defences, sealing manholes and flow diversion   | €17,838,862 | €9,457,249                           | 1925      | 1.89 | 204                               |

refer to section B4 for the full MCA tables

#### 7. Assessment of Preferred FRM Options Summary

The assessment has identified three possible options with favourable BCR and MCA BCR scores. All options comprise elements of hard defences and accompanying works including sealing manholes. The addition of flow diversion or upstream storage are the two most favourable alternatives as both measures address flow from the upstream catchment and reduce the length and height of hard defences downstream. However as all options achieved required MCA and BCR scores, all options were selected to be brought forward for consultation.

Consultation allows for refinement by the incorporation of localised secondary measures. Maintenance, planning and development control, building regulations, are also integral to supporting these options at a High Priority Watercourse spatial scale of assessment.

#### Recommended Options to Proceed to Consultation Option 1 Hard defences, sealing manholes.

Option 2 Hard defences, sealing manholes and upstream storage.
Option 3 Hard defences, sealing manholes and flow diversion.

#### 8. Refinement of options

Preferred FRM options identified, no refinement required

costs include for unmeasured items, optimism bias, maintenance, design, supervision and monitoring



#### 9. Updated Preferred Options

Post consultation recommendations were considered and the updated Preferred FRM options are as follows:

- Hard defences (flood walls and embankments)
  - o either with flood storage
  - o or with flow diversion
- Sealing manholes
- Culvert inlet screens
- Flap Valves
- Maintenance plan



#### Section B1 - Comments on the technical review

| FRM Method                        | Comment   |
|-----------------------------------|---|
| Do Nothing                        | Due to the existing flood risk in the River Poddle area being studied the Do Nothing FRM method is deemed unacceptable socially and economically.   |
| Maintain Existing Regime          | This measure is to be kept as the baseline condition. DCC and SDCC assist in the maintenance of the River Poddle. All screens are checked and cleared on a weekly cycle and when bad weather warnings occur. Important structures on the Poddle are also monitored using CCTV camera and culvert screen upgrades including secondary screen upstream have been constructed.   |
| Do Minimum                        | This measure is considered unacceptable socially and economically as increased risk and damage may result from a less effective maintenance programme than is currently being implemented with insignificant cost saving.   |
| Maintenance programme             | There is currently a high level of maintenance already occurring on the Poddle due to the history of rubbish tipping and blockages. While measures to improve the maintenance programme would be beneficial in reducing the flood risk there would be limited effect in reducing the overall flood risk. This measure should therefore be placed in the secondary measures list and considered further at detailed design phase or if the primary measures are found to be unsuitable.  |
| Upstream storage/storage          | Tymon Park has been identified as a potential storage area using the existing ponds and raising the banks around them to create further storage. In order to be effective the flow needs to be reduced to the equivalent of the 50%AEP flood event. This will require a maximum flow of 3.25 cumecs to be released downstream of the storage. This measure can reduce the flow to 3 cumecs at the downstream boundary of Tymon Park and would therefore be considered effective in significantly reducing the flood risk immediately downstream with a small number of properties at risk upstream of Tymon Park to be addressed separately. However flooding to receptors from the more downstream urban catchment remains to be addressed and therefore this measure will need to be used along with another measure.   |
| Tidal barrage/Flap valve          | The Poddle is influenced by the Liffey water levels which are affected by the tide. A flap valve at the end of the Poddle culvert could prevent this influence occurring although the principle source of flood risk is fluvial and therefore will have minimal impact. This measure should therefore be placed in the secondary measures list and considered further if the primary measures are found to be unsuitable.   |
| Improvement of channel conveyance | 5 culverts and 5 weirs have been identified as restricting conveyance and causing raised water levels to some degree. The resulting water levels from upgrading or removing culverts had limited impact on the overall flood risk and would require additional FRM methods to alleviate the flood risk. Additionally the flood risk downstream of the culverts would increase slightly require further FRM methods in the affected locations. No weirs were identified as having potential to significantly reduce flood risk either and the removal of some weirs could potentially increase the flood risk downstream. Due to the controlled nature of the Poddle, ie the high density of culverts, bridges and weirs the affect of increasing the channel capacity would be minimal and limited to where space allowed. The sluice gate at the Poddle - Dodder diversion overflow structure has been identified as a significant water level control. Whilst the modification of this structure could reduce the upstream water level it would not completely reduce the upstream flood risk during the design event and may cause increased flooding downstream. The improvement of channel conveyance (such as increasing the conveyance of the culvert at Ravensdale Park and/or the removal of the sluice gate at the Poddle - Dodder flow diversion) will not mitigate the flood risk during the design event entirely and should therefore be considered as a localised, secondary measure at detailed design phase or if the primary measures are found to be unsuitable. |
| Hard defences                     | Hard defences would consist of flood walls and earth embankments located where the river banks are low relative to water level. Approximately 2.5km of flood defence would be required and could be implemented either without the need of any additional measures or along with certain other measures. Ancillary works will   |



| FRM Method                          | Comment  |
|-------------------------------------|--|
|                                     | be required with hard defences such as pumping stations and/or storage tanks to account for pluvial drainage routes being cut off from the river.  |
| Relocation of properties            | 922 properties would be required to be relocated. It is considered that this would an excessively socially complex measure to implement in practice and while technically feasible should be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.   |
| Culverting                          | Approximately 1.5 km of culvert would be required. This measure is feasible but is considered an excessively technically complex measure to implement in practice due to the numerous existing culverts, bridges, weirs and utility services to remove or incorporate some of which have archaeological significance. The pumping of the Poddle during construction in restricted spaces would add to the complexity also. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.  |
| Diversion of flow                   | A suitable diversion route has been identified from the Poddle to the Dodder along Tymon Park running south of the M50. In order to be effective the flow needs to be reduced to the equivalent of the 50%AEP flood event. This will require a flow of 3.25 cumecs to be diverted. At the location of the flow diversion the 1%AEP event flow is 4.53 cumecs. The diversion route is approximately 1km and falls 10m discharging downstream of the weir at Mount Carmel Park. A 1.5 diameter pipe would be required to convey 3.25 cumecs of water. Flow diversion will reduce the flood risk significantly but not entirely during the design event and therefore this measure will need to be used along with another measure.   |
| Overland floodways                  | Overland floodways may be feasible in certain localised areas along the Poddle however this measure is deemed to be an excessively technically complex measure to implement in practice due to the heavily urbanised nature of the catchment. Finding suitable roads to use as floodways without increasing the flood risk or disruption to traffic and property owners/users would be technically and socially difficult as would finding a suitable discharge point back into the Poddle. This measure would reduce the flood risk along particular reaches of the river and would therefore have limited impact. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable. |
| Rehabilitation of existing defences | There are existing flow diversion located on the River Poddle. The diversion at Kimmage discharges to ponds in the River Dodder Catchment. The diversion at Harolds Cross discharges to the Grand Canal Sewer. Both defences are operating well and there was no requirement to rehabilitate them – this measure was not shortlisted.  |
| Localised protection works          | Along certain reaches of the Poddle low river banks result in a flood risk. There is potential to infill in these gaps albeit with limited impact on the overall flood risk. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.  |
| Flood warning/forecasting           | Flood warning/forecasting would not be effective at HPW scale in reducing the impact of flooding. This is due to the "flashy" nature of the River Poddle and limited warning time available. This measure should be kept as a possible Unit of Management 09 scale measure in order to minimise impact and address residual flood risk. This measure should therefore be placed in the secondary measures list and considered further, through MCA, at plan stage.   |
| Public awareness campaign           | A public awareness campaign can be used at any SSA and it's effectiveness is often dependant on other FRM methods being used at the same time. The public awareness campaign will therefore be considered at UoM and sub-catchment scale also. Considering the Poddle HPW the public awareness campaign will have limited impact on reducing the flood risk as a standalone option. This measure should therefore be placed in the secondary measures list and considered further if required.   |



| FRM Method                     | Comment   |
|--------------------------------|---|
| Individual property protection | It would be deemed to be ineffective to implement this measure for all 922 properties as the full standard of flood protection could not be assured and a high social impact would still remain. This measure may become effective on a local scale where isolated properties could benefit from it. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable. |
| Sealing manholes               | At the downstream end of the Poddle where the river is fully culverted a food risk is present from manholes surcharging. 20 manholes have been identified as surcharging, sealing these manholes would prevent the flood risk from this source. This measure is considered a primary measure for this downstream area.  |



#### Section B2 - Comments on the environmental and social review

| FRM Method        | Environmental Comment | Social Comment   |  |  |  |  |
|-------------------|-----------------------|--|--|--|--|--|
| Hard defences     | N/A                   | Potential impacts to the tentative Unesco designation in the Poddle catchment must be considered.        |  |  |  |  |
| Diversion of flow |                       | Potential impacts to Unesco sites in or directly adjacent to the receiving catchment must be considered. |  |  |  |  |



#### Section B3 - Developing potential FRM options

#### Full list of FRM methods after stage 4 review

| FRM Method               |                    | Abbreviation |
|--------------------------|--------------------|--------------|
| Maintain Existing Regime | Baseline           | ER           |
| Upstream storage/storage | Current flood risk | S            |
| Hard defences            | Current flood risk | D            |
| Diversion of flow        | Current flood risk | DF           |
| Sealing manholes         | Current flood risk | SM           |

#### Notes:

- Hard defences will be required to some degree for all options as no other option can provide the required SOP alone.
- Sealing manholes will be required for all options and this is the only measure to address the flooding at the downstream reach of the Poddle.
- Upstream storage and diversion of flow measures should not be combined in an option. This is due to both options managing the flood risk in the same way (reducing flow in the Poddle). Diverting the flow from the Poddle would result in no significant flow requiring storage.
- All options must provide the preferred SOP (1% AEP Event).
- The baseline FRM method will carry on through the process for comparative purposes

Potential FRM options can consist of a single or multiple FRM methods. The tables below display the matrices used to identify the various FRM methods other than the baseline condition. Each table identifies FRM options with one, two and three FRM methods respectively. An "x" denotes where a combination of FRM methods is unacceptable by failing the meeting the requirements as set out in the bullet points above. A "o" denotes an acceptable FRM option to be assessed further. Where a box has been greyed out it is due to the FRM option already being considered elsewhere in the matrix or where same FRM method is being considered twice.

| 1 FRM Methods | S | D | DF | SM |
|---------------|---|---|----|----|
|               | Х | Х | Х  | Х  |

| 2 FRM Methods | S | D | DF | SM |
|---------------|---|---|----|----|
| S             |   |   |    |    |
| D             | Х |   |    |    |
| DF            | Х | х |    |    |
| SM            | Х | 0 | Х  |    |

| 3 FRM Methods | D  |
|---------------|----|
|               | SM |
| S             | 0  |
| D             | Х  |
| DF            | 0  |
| SM            | Х  |

|                 | FRM Methods              |                  |                          |
|-----------------|--------------------------|------------------|--------------------------|
| Baseline Option | Maintain Existing Regime |                  |                          |
| Option 1        | Hard defences            | Sealing manholes |                          |
| Option 2        | Hard defences            | Sealing manholes | Upstream storage/storage |
| Option 3        | Hard defences            | Sealing manholes | Diversion of flow        |

Poddle HPW Option 1 - Hard defences and sealing manholes

|               |   |  |  |   |  | GLOBAL    | LOCAL<br>WEIGHTING  | LOCAL WEIGHTING<br>COMMENT   | SCORE                           | SCORE COMME  | ENT   | WEIGHTE |
|---------------|---|--|--|---|--|-----------|---------------------|--|---------------------------------|--|---|---------|
| CRITERIA      | OBJECTIVE   | SUB-OBJECTIVE  | INDICATOR  | BASIC REQUIREMENT   | ASPIRATIONAL TARGET  | WEIGHTING | Local<br>Importance | International<br>Importance  | Does not meet<br>Basic Requirms | Meets Basic<br>Requirement   | Meets Aspirational<br>Target                            | SCORE   |
| chnical       | a Ensure flood risk management options are operationally robust   | i) Ensure flood risk management options are operationally robust   | Level of operational risk of option  • Degree of reliance on mechanical, electrical or electronic systems or on human intervention, action or decision, for the option to operate or perform successfully  • Non-numeric   |   | No operational risk, i.e., no reliance on mechanical, electrical n or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully | 20        | ·                   | Constant at 5  | 3                               | For the majority of this option there is no of locations pumping stations are required for Minimal maintenance will be required for the embankments  | surface water flood risk.                               |         |
|               | b Minimise health and safety risks<br>associated with the construction<br>and operation of flood risk<br>management options | Minimise health and safety risks associated<br>with the construction and operation of flood risk<br>management options   | Degree of health and safety risk during construction and operation   | Acceptable and manageable level of health and safety risk   | No risk to health and safety during either construction or operation   | 20        |                     | Constant at 5  |                                 | Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations (-1) Diectrical work (-1)   |   |         |
|               | c Ensure flood risk management options are adaptable to future flood risk   | Ensure flood risk management options are<br>adaptable to future flood risk   | Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change  |   | Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the HEFS                         |           |                     | Constant at 5  |                                 | 0 - option adaptable to MRFS with difficult) 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 25 - option provides HEFS |   |         |
| conomic       | a Minimise economic risk  | i) Minimise economic risk  | Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits   | AAD is not increased  | 100% reduction in AAD  | 20        | ;                   | Constant at 5  |                                 | Scoring considers the percentage of AAD during the 1% AEP event compared to the event with a max score of 5 for 100%   |   | ,       |
|               | b Minimise risk to transport infrastructure   | i) Minimise risk to transport infrastructure   | Number of transport routes (road, rail, navigation) at risk from flooding (0.1% AEP Event)   | No increase in the number of transport routes at risk   | All transportation routes protected  | 30        |                     | Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Nimor Road - 1                        |                                 | 4 Scoring considers the percentage of recep scheme option during the 1% AEP event creceptors at risk during the 0.1% AEP even 100%   | ompared to the existing                                 |         |
|               | c Minimise risk to utility infrastructure   | i) Minimise risk to utility infrastructure   | Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges, etc) at risk from flooding (0.1% AEP Event)   | No increase in the number of utility infrastructure assets at risk  | All utility infrastructure assets protected  | 10        |                     | 1 ESB substation at risk with a "low" vulnerability  |                                 | Scoring considers the percentage of recep scheme option during the 1% AEP event c receptors at risk during the 0.1% AEP even 100%  | ompared to the existing                                 |         |
|               | d Manage Risk to Agricultural Land  | i) Manage Risk to Agricultural Land  | Area of agricultural land at risk from flooding (based on CORINE data or other)  | No increase on agricultural land at risk  | All agricultural land protected  | 10        |                     | No significant area of agricultural land at risk   |                                 | Scoring considers the percentage of recep scheme option during the 1% AEP event c receptors at risk during the 0.1% AEP even 100%  | ompared to the existing                                 |         |
| ocial         | a Minimise risk to human health and life  | i) Minimise risk to human health and life of residents   | Number of residential properties at risk from flooding (0.1% AEP Event)  | No additional (or substitution of) residential properties at risk from flooding   | No residential properties at risk from flooding  | 30        |                     | due to high population   |                                 | Scoring considers the percentage of recep scheme option during the 1% AEP event c receptors at risk during the 0.1% AEP event 3 100%   | ompared to the existing                                 |         |
|               |   | ii) Minimise risk to high vulnerability properties   | Number of high vulnerability properties (hospitals, residential homes for the sick, elderly, infirm and children) at risk from flooding (0.1% AEP Event)   |   | No vulnerable properties at risk from flooding   | 10        | 2                   | No high vulnerability properties at risk during the 1% AEP event   |                                 | Scoring considers the percentage of receptions scheme option during the 1% AEP event conceptors at risk during the 0.1% AEP event 2 100%   | ompared to the existing                                 |         |
|               | b Minimise risk to community  | i) Minimise risk to social infrastructure  | Number of high value soical infrastructural assets (first responders, govt buildings) at risk from flooding (0.1% AEP Event)   | infrastructural assets at risk from flooding  | No high value social infrastructural assetts at risk from flooding   | 5         |                     | no first reponders, no major govt offices at risk during the 1% AEP event  |                                 | Scoring considers the percentage of reception scheme option during the 1% AEP event coreceptors at risk during the 0.1% AEP event 0 100%   | ompared to the existing<br>nt with a max score of 5 for |         |
|               |   | iii) Minimise risk to local employment   | Number of non-residential properties (fire stations, Garda stations) at risk from flooding (0.1% AEP Event)  | risk from flooding  |  | 10        | Į.                  | high density of commerical activity  |                                 | Scoring considers the percentage of recep scheme option during the 1% AEP event c receptors at risk during the 0.1% AEP event 2 100%   | ompared to the existing<br>nt with a max score of 5 for |         |
|               | c Minimise risk to flood-sensitive social amenity sites   | Minimise risk to flood-sensitive social amenity<br>sites   | Number of amenity sites at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) amenity sites at risk from flooding  | No amenity sites at risk from flooding   | 5         | 2                   | 1 community centre, 2 sports<br>club/leisure centre and playing fields at<br>risk<br>2   |                                 | Scoring considers the percentage of recep scheme option during the 1% AEP event c receptors at risk during the 0.1% AEP even 5 100%  | ompared to the existing                                 |         |
| Environmental | a Support the objectives of the WFD   | Prevent deterioration in status, and if possible<br>contribute to the achievement of good<br>ecological status / potential of water-bodies   | Ecological status of water bodies  | Provide no constraint associated with flood risk management options to the achievement of good status/potential   | Significant contribution of flood risk management options to<br>the achievement of good status/potential   | 10        |                     | WFD objectives must be achieved in all<br>water bodies so this objective should<br>always have the maximum local<br>weighting                                |                                 | Reduction in flooding will reduce input of or<br>catchment which could have benefits for w   |   |         |
|               | b Minimise the risk to potential sources of environmental pollution   | Minimise the risk to potential sources of<br>environmental pollution   | Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and 92/271/EC)   | risk from flooding due to the implementation of the flood risk management option  | implementation of the flood risk management option   | 10        |                     | No receptors in 1% AEP flood extent  |                                 | Achieves basic target in that no additional of   |   |         |
|               | c Support the objectives of the Habitats Directive  | European protected Natura 2000 sites   | Reported conservation status of Natura 2000 sites relating to flood risk management  | due to the implementation of the flood risk management option   | to the implementation of the flood risk management option  | 10        |                     | No receptors in 1% AEP flood extent,<br>AA has screened out any impacts  |                                 | Achieves basic target in that no additional of   |   |         |
|               | d Avoid damage to, and where possible enhance, the flora and fauna of the catchment   | <ul> <li>Avoid loss/damage to, and where possible<br/>enhance, nationally protected sites of nature<br/>conservation importance i.e. (p)NHA, Ramsar</li> </ul>                     | Reported conservation status of designated sites relating to flood risk management   | No deterioration in conservation status of sites due to the<br>implementation of the flood risk management option   | Improvement in conservation status of sites due to the<br>implementation of the flood risk management option   | 2.5       |                     | No receptors in 1% AEP flood extent  |                                 | Achieves basic target in that no additional  | eceptors are affected                                   |         |
|               |   | ii) Avoid loss / damage and where possible enhance, legally protected species and other known species of conservation concern  | Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ("target species")   | No loss of integrity of suitable habitat supporting legally protected species and other known species of conservation concern due to the implementation of the flood risk management option | No loss of suitable habitat supporting legally protected<br>species and other known species of conservation concern<br>due to the implementation of the flood risk management<br>option  | -         |                     | Local habitats and species of interest including grassland, woodland and trees. Conservation objectives in development plans                                 |                                 | Achieves basic target in that no receptors a   | are affected  |         |
|               | e Protect, and where possible enhance, fisheries resource within the catchment  | Maintain existing, and where possible create<br>new, fisheries habitat including the<br>maintenance or improvement of conditions that<br>allow upstream migration for fish species | Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers   | No loss of integrity of fisheries habitat, maintenance of upstream accessibility  | No loss of fisheries habitat, improvement in habitat quality and/or quality, enhanced upstream accessibility   | 2.5       |                     | The river is culverted for long stretches in lower reaches, not suitable for fisheries   |                                 | Achieves basic target in that no receptors a   | are affected  |         |
|               |   | ii) Protect, and where possible enhance, the quality of shellfish waters   | Classification of shellfish waters   | No detertioration in shellfish water quality parameter values due to the implementation of the flood risk management  | Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option  | 2.5       |                     | Nearest shellfish area is geographically<br>remote at the other side of Howth Head   |                                 | Achieves basic target in that receptors are implementation of the option   | not negatively affected by                              |         |
|               | f Protect, and where possible enhance, landscape character and visual amenity within the river corridor                     | i) Protect, and where possible enhance, visual amenity   | Compliance with Landscape Character Objectives for the catchment   | Protection of the Landscape Character of the Catchment  | Enhancement of the Landscape Character within the Catchment  | 2.5       |                     | Stretch of river listed in RMP. Landscape objectives outlined in development plans   |                                 | Walls and embankments are likely to have landscape and views   | a negative impact on                                    |         |
|               |   | i) Avoid damage to or loss of features of architectural value and their setting  | No. of Architectural Conservation Areas (ACAs), Record of Protected Structures (RPS) in the County Development Plans and NIAH sites of regional and above rating at risk from flooding.  |   | No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.  | 2.5       |                     | Architectural designations and objectives in development plans   |                                 | Achieves basic target in that receptors are implementation of the option   | not negatively affected by                              |         |
|               |   | ii) Avoid damage to or loss of features of archaeological value and their setting  | Number of UNESCO World Heritage Sites (including candidate UNESCO World Heritage Sites), National Monuments including Temporary Preservation Orders and Register of Historic Monuments, Potential National Monuments in Local Authority Ownership where known), and Recorded Archaeological Sites/Monuments (RMP sites) at risk from flooding. |   | No archaeological heritage at risk from flooding and<br>enhanced protection of sites due to the implementation of the<br>option.   |           |                     | 1x monument in 1% AEP floodplain. Part of catchment is proposed Unesco site. Stretch of river listed in RMP. Archaeological objectives in development plans. |                                 | Sites protected from flooding but option co<br>on archaeological character and undiscove   |   |         |
|               | h Protect soil function   | i) Avoid loss of soil from erosion   | The area of land which is at risk or currently experiencing erosion from flooding  | No increase in the quantity of land at risk from soil erosion   | A reduction in the quantity of land at risk from soil erosion  | 2.5       |                     | Urban catchment with walled banks in most places   |                                 | 0 highly urbanised catchment with few green 0 scope for bare soils   |   |         |
|               | Minimise detrimental impacts of<br>climate change on the environment<br>resulting from flood risk                           | Minimise detrimental impacts of climate change<br>on the environment resulting from flood risk<br>management activities  | Number of flood sensitive environmental receptors at risk during   | No increase in number of environmental receptors at risk during the MRFS  | Reduction in number of environmental receptors at risk during the HEFS   |           |                     | Number of environmental receptors at risk is the same for the MRFS and the HEFS (1 ACA, 12 SMR)  |                                 | All environmental receptors at risk during N by proposed option SoP  | IRFS and HEFS protected                                 |         |

Poddle HPW Option 2 - Hard defences, sealing manholes and Tymon Park storage

|      |   |   |  |  |  | GLOBAL    | LOCAL<br>WEIGHTING  | LOCAL WEIGHTING<br>COMMENT   | SCORE                           | SCORE COMMENT   |       |
|------|---|---|--|--|--|-----------|---------------------|--|---------------------------------|---|-------|
|      | OBJECTIVE   | SUB-OBJECTIVE   | INDICATOR  | BASIC REQUIREMENT  | ASPIRATIONAL TARGET  | WEIGHTING | Local<br>Importance | International<br>Importance  | Does not meet<br>Basic Requirme | Meets Basic Meets Aspirations Requirement Target  | al I  |
|      |   | i) Ensure flood risk management options are   |  | Manageable degree of operational risk, i.e., degree of   |  |           | '                   | Constant at 5  | -5                              | For the majority of this option there is no operational risk minim  |       |
|      | options are operationally robust  | operationally robust  | Degree of reliance on mechanical, electrical or electronic<br>systems or on human intervention, action or decision, for the<br>option to operate or perform successfully   | reliance on mechanical, electrical or electronic systems, on human intervention, action or decision can be met and is acceptable given the risks / consequences of failure                 | or electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully  |           |                     |  |                                 | maintenance will be required for the 180m of flood embankme   | ents  |
|      | h Minimica hoalth and cafety ricks  | i) Minimise health and safety risks associated  | Non-numeric  |  |  | 20        | 5                   | Constant at 5  |                                 | Options involved:   |       |
|      | b Minimise health and safety risks<br>associated with the construction<br>and operation of flood risk<br>management options | with the construction and operation of flood<br>risk management options   | Degree of health and safety risk during construction and operation   | Acceptable and manageable level of health and safety his   | operation  |           |                     | Constant at 5  |                                 | Options involved: construction work (heavy plant) (-1) restricted access (-1) Modeling access (-1)  |       |
|      | c Ensure flood risk management  | Ensure flood risk management options are  | Sustainability and adaptability of the flood risk management   | Option to provide for, or be adaptable to, the MRFS in   | Option to provide for, or be adaptable to, the HEFS in   | 20        | 5                   | Constant at 5  |                                 | 2 Working near water (-1) 0 - option adaptable to MRFS with difficulty  |       |
|      | options are adaptable to future flood risk  | adaptable to future flood risk  | measure in the face of potential future changes, including the potential impacts of climate change   | terms of maintaining the standard of protection OR Option avoids any additional flood risk under the MRFS  | terms of maintaining the standard of protection OR Option avoids any additional flood risk under the HEFS  |           |                     |  |                                 | option adaptable to MRFS     option provides MRFS     option adaptable to HEFS with difficulty  |       |
|      |   |   |  |  |  | 20        | 5                   |  |                                 | 4 - option adaptable to HEFS<br>4 5 - option provides HEFS  |       |
|      | a Minimise economic risk  | i) Minimise economic risk   | Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits   | AAD is not increased   | 100% reduction in AAD  | 20        |                     | Constant at 5  |                                 | Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during to 0.1% AEP event with a max score of 5 for 100%   | the   |
|      |   | i) Minimise risk to transport infrastructure  | Number of transport routes (road, rail, navigation) at risk from   | No increase in the number of transport routes at risk  | All transportation routes protected  | 30        |                     | Up to a Regional road at risk (Inc   |                                 | Scoring considers the percentage of receptors protected under   |       |
|      | infrastructure  |   | flooding (0.1% AEP Event)  |  |  |           |                     | Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2  |                                 | scheme option during the 1% AEP event compared to the exist receptors at risk during the 0.1% AEP event with a max score of to 100%   |       |
|      | c Minimise risk to utility  | Minimise risk to utility infrastructure   | Number of utility infrastructure assets (power stations, WWTWs,  | No increase in the number of utility infrastructure assets a   | tt All utility infrastructure assets protected   | 10        | 3                   | Minor Road - 1  1 ESB substation at risk with a "low"  |                                 | Scoring considers the percentage of receptors protected under   | r the |
|      | infrastructure  |   | WTWs, telecom exchanges, etc) at risk from flooding (0.1% AEP Event)   | risk   |  |           |                     | vulnerability  |                                 | scheme option during the 1% AEP event compared to the exist receptors at risk during the 0.1% AEP event with a max score of for 100%  |       |
|      | d Manage Risk to Agricultural Land  | i) Manage Risk to Agricultural Land   | Area of agricultural land at risk from flooding (based on CORINE   | No increase on agricultural land at risk   | All agricultural land protected  | 10        | 2                   | No significant area of agricultural land   |                                 | Scoring considers the percentage of receptors protected under   |       |
|      |   |   | data or other)   |  |  | 10        |                     | at risk  |                                 | scheme option during the 1% AEP event compared to the exist receptors at risk during the 0.1% AEP event with a max score of for 100%  |       |
|      | a Minimise risk to human health and   | i) Minimise risk to human health and life of  | Number of residential properties at risk from flooding (0.1% AEP   |  | No residential properties at risk from flooding  | 10        |                     | due to high population   |                                 | Scoring considers the percentage of receptors protected under   |       |
|      | life  | residents   | Event)   | risk from flooding   |  | 30        | 5                   |  | :                               | scheme option during the 1% AEP event compared to the exist receptors at risk during the 0.1% AEP event with a max score of for 100%  |       |
|      |   | ii) Minimise risk to high vulnerability properties  | Number of high vulnerability properties (hospitals, residential homes for the sick, elderly, infirm and children) at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) vulnerable properties at risk from flooding   | No vulnerable properties at risk from flooding   | 10        |                     | No high vulnerability properties at risk<br>during the 1% AEP event  |                                 | Scoring considers the percentage of receptors protected under<br>scheme option during the 1% AEP event compared to the exist<br>receptors at risk during the 0.1% AEP event with a max score of<br>1 for 100% | ting  |
|      | b Minimise risk to community  | i) Minimise risk to social infrastructure   | Number of high value soical infrastructural assets (first responders, govt buildings) at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) high value social infrastructural assets at risk from flooding  | No high value social infrastructural assetts at risk from flooding   | 10        | 2                   | no first reponders, no major govt offices at risk during the 1% AEP event  |                                 | Scoring considers the percentage of receptors protected under<br>scheme option during the 1% AEP event compared to the exist<br>receptors at risk during the 0.1% AEP event with a max score of               | ting  |
|      |   | ii) Minimise risk to local employment   | Number of non-residential properties (fire stations, Garda stations)   | No additional (or substitution of) non-residential properties  | s No non-residential properties at risk from flooding  | 5         | 2                   | high density of commerical activity  |                                 | 0 for 100%  Scoring considers the percentage of receptors protected under   | r the |
|      |   |   | at risk from flooding (0.1% AEP Event)   | at risk from flooding  |  | 10        | F                   | ,  |                                 | scheme option during the 1% AEP event compared to the exist receptors at risk during the 0.1% AEP event with a max score of for 100%  | ting  |
|      | c Minimise risk to flood-sensitive social amenity sites   | i) Minimise risk to flood-sensitive social amenity sites  | Number of amenity sites at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) amenity sites at risk from flooding   | No amenity sites at risk from flooding   | 10        |                     | 1 community centre, 2 sports<br>club/leisure centre and playing fields<br>at risk  |                                 | Scoring considers the percentage of receptors protected under<br>scheme option during the 1% AEP event compared to the exist<br>receptors at risk during the 0.1% AEP event with a max score of               | ting  |
| ntal | a Support the objectives of the WFD   | Prevent deterioration in status, and if possible  | Ecological status of water bodies  | Provide no constraint associated with flood risk   | Significant contribution of flood risk management options to   | 5         | 2                   | WFD objectives must be achieved in   |                                 | 5 for 100%  Reduction in flooding will reduce input of contaminants from th   | ne .  |
|      |   | contribute to the achievement of good ecological status / potential of water-bodies   |  | management options to the achievement of good status/potential   | the achievement of good status/potential   | 10        |                     | all water bodies so this objective<br>should always have the maximum<br>local weighting  |                                 | catchment which could have benefits for water status  |       |
|      | sources of environmental  | i) Minimise the risk to potential sources of environmental pollution  | Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and  | at risk from flooding due to the implementation of the floo  | No potential pollution sources at risk from flooding due to d the implementation of the flood risk management option   | 10        |                     | No receptors in 1% AEP flood extent  |                                 | Achieves basic target in that no additional receptors are put at  | risk  |
|      | c Support the objectives of the Habitats Directive  | Avoid damage to, and where possible<br>enhance, European protected Natura 2000  | 92/271/EC) Reported conservation status of Natura 2000 sites relating to flood risk management   |  | es Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management  | 10        |                     | No receptors in 1% AEP flood extent,<br>AA has screened out any impacts  | '                               | Achieves basic target in that no additional receptors are affecte   | ed    |
|      | d Avoid damage to, and where possible enhance, the flora and fauna of the catchment   | sites i) Avoid loss/damage to, and where possible enhance, nationally protected sites of nature conservation importance i.e. (p)NHA, Ramsar | Reported conservation status of designated sites relating to flood risk management   | option  No deterioration in conservation status of sites due to the implementation of the flood risk management option   | option Improvement in conservation status of sites due to the implementation of the flood risk management option   | 10        | 1                   | No receptors in 1% AEP flood extent  |                                 | O Achieves basic target in that no additional receptors are affecte   | ed    |
|      |   | ii) Avoid loss / damage and where possible<br>enhance, legally protected species and other<br>known species of conservation concern         | Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ("target species")   | No loss of integrity of suitable habitat supporting legally protected species and other known species of conservatic concern due to the implementation of the flood risk management option | No loss of suitable habitat supporting legally protected<br>on species and other known species of conservation concern<br>due to the implementation of the flood risk management<br>ootion | 2.5       | '                   | Local habitats and species of interest including grassland, woodland and trees. Conservation objectives in development plans                                 | '                               | Works in Tymon Park could have temporary and inermittent negative effects   |       |
|      | e Protect, and where possible enhance, fisheries resource within the catchment  |   | Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers   | No loss of integrity of fisheries habitat, maintenance of upstream accessibility   | No loss of fisheries habitat, improvement in habitat quality and/or quality, enhanced upstream accessibility   | 2.5       | 3                   | The river is culverted for long stretches in lower reaches, not suitable for fisheries   | -                               | 2 Achieves basic target in that no receptors are affected   |       |
|      |   | ii) Protect, and where possible enhance, the quality of shellfish waters  | Classification of shellfish waters   |  | es Improvement in shellfish water quality parameter values due to the implementation of the flood risk management  | 2.5       |                     | Nearest shellfish area is geographically remote at the other   |                                 | Achieves basic target in that receptors are not negatively affect by implementation of the option   | ted   |
|      | f Protect, and where possible enhance, landscape character and visual amenity within the river                              | amenity   | Compliance with Landscape Character Objectives for the catchment   | option  Protection of the Landscape Character of the Catchment   | option  Enhancement of the Landscape Character within the Catchment  | 2.5       |                     | side of Howth Head  Stretch of river listed in RMP.  Landscape objectives outlined in development plans  |                                 | Topography of Tymon Park will be signigicantly changed, view: lake will be screened by high embankments, walls and 4 embankments in the rest of the catchment could negatively aff                            |       |
|      | g Avoid damage to or loss of<br>features of cultural heritage<br>importance and their setting                               | i) Avoid damage to or loss of features of architectural value and their setting   | No. of Architectural Conservation Areas (ACAs), Record of<br>Protected Structures (RPS) in the County Development Plans and<br>NIAH sites of regional and above rating at risk from flooding .   | No additional architectural areas / structures at risk from flooding and no detrimental impacts on the architectural heritage setting as a reuslt of implementation of the option          | enhanced protection of sites due to the implementation of  | 5         | . 4                 | Architectural designations and objectives in development plans   | -                               | Achieves basic target in that receptors are not negatively affect by implementation of the option   |       |
|      |   | Avoid damage to or loss of features of archaeological value and their setting   | Number of UNESCO World Heritage Sites (including candidate UNESCO World Heritage Sites), National Monuments including Temporary Preservation Orders and Register of Historic Monuments, Potential National Monuments in Local Authority Ownership where Known), and Recorded Archaeological Sites/Monuments (RMP sites) at risk from flooding. | No additional archaeological sites / features at risk from   | No archaeological heritage at risk from flooding and all enhanced protection of sites due to the implementation of   | 2.5       | 3                   | 1x monument in 1% AEP floodplain. Part of catchment is proposed Unesco site. Stretch of river listed in RMP. Archaeological objectives in development plans. |                                 | Sites protected from flooding but option could have detrimenta effect on archaeological character and undiscoverd archaeological character.   |       |
|      | h Protect soil function   | i) Avoid loss of soil from erosion  | The area of land which is at risk or currently experiencing erosion from flooding  | No increase in the quantity of land at risk from soil erosion  | A reduction in the quantity of land at risk from soil erosion  | 2.5       |                     | Urban catchment with walled banks in   |                                 | 0 highly urbanised catchment with few green areas and not mucl  | :h    |
|      | Minimise detrimental impacts of<br>climate change on the<br>environment resulting from flood<br>risk management activities  | Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities                           | from nooding  Number of flood sensitive environmental receptors at risk during climate change flood events   | No increase in number of environmental receptors at risk during the MRFS   | Reduction in number of environmental receptors at risk during the HEFS   | 5         | 1                   | most places Number of environmental receptors at risk is the same for the MRFS and the HEFS (1 ACA, 12 SMR)  |                                 | Ol scope for bare soils     All environmental receptors at risk during MRFS and HEFS protected by proposed option SoP   |       |

Section B4 - Multi Criteria Analysis

| DITEDIA    | OR IFOTIVE  | CUP OR IECTIVE   | INDICATOR  | DACIO DEGLUDEMENT  | ACDIDATIONAL TARCET   | GLOBAL    | LOCAL<br>WEIGHTING  | LOCAL WEIGHTING<br>COMMENT  | SCORE                             | SCORE COMMI  | ENT   | WEIGHT |
|------------|---|--|--|--|---|-----------|---------------------|---|-----------------------------------|--|---|--------|
| RITERIA    | OBJECTIVE   | SUB-OBJECTIVE  | INDICATOR  | BASIC REQUIREMENT  | ASPIRATIONAL TARGET   | WEIGHTING | Local<br>Importance | International<br>Importance<br>5  | Does not meet<br>Basic Requirment | Meets Basic<br>Requirement<br>0  | Meets Aspirational<br>Target                          | SCORE  |
|            | a Ensure flood risk management options are operationally robust   | i) Ensure flood risk management options are operationally robust   | Level of operational risk of option  • Degree of reliance on mechanical, electrical or electronic systems or on human intervention, action or decision, for the option to operate or perform successfully  • Non-numeric   | Manageable degree of operational risk, i.e., degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision can be met and is acceptable given the risks / consequences of failure | electrical or electronic systems, or on human intervention,   | 20        | 5                   | Constant at 5   | over<br>will i                    | w control structure will be present at<br>flow weir although should not require<br>ncrease at the overflow structure alo<br>n embankments elsewhere.             | e operation Maintenance                               |        |
|            | b Minimise health and safety risks<br>associated with the construction<br>and operation of flood risk<br>management options | i) Minimise health and safety risks associated with the construction and operation of flood risk management options  | Degree of health and safety risk during construction and operation   | Acceptable and manageable level of health and safety risk  | No risk to health and safety during either construction or operation  | 20        | F                   | Constant at 5   | cons<br>restr<br>Wor              | ons involved:<br>struction work (heavy plant) (-1)<br>icted access (-1)<br>king near water (-1)<br>p excavations (-1)  |   |        |
|            | c Ensure flood risk management options are adaptable to future flood risk   | Ensure flood risk management options are<br>adaptable to future flood risk   | Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change  | Option to provide for, or be adaptable to, the MRFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the MRFS   | Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the HEFS                        | 20        |                     | Constant at 5   | 1 - c<br>2 - c<br>3 - c<br>4 - c  | ption adaptable to MRFS with difficu<br>ption adaptable to MRFS<br>ption provides MRFS<br>ption adaptable to HEFS with difficul<br>ption adaptable to HEFS       |   |        |
| nomic      | a Minimise economic risk  | i) Minimise economic risk  | Annual Average Damage (AAD) expressed in Euro / year,<br>calculated in accordance with the economic risk assessment<br>methods, but with no allowance for social / intangible benefits   | AAD is not increased   | 100% reduction in AAD   | 20        |                     | Constant at 5   | Scor                              | ption provides HEFS ring considers the percentage of AAL on during the 1% AEP event compare 6 AEP event with a max score of 5 fo                                 | ed to the AAD during the                              |        |
| -          | b Minimise risk to transport infrastructure   | i) Minimise risk to transport infrastructure   |  | No increase in the number of transport routes at risk  | All transportation routes protected   | 30        | Ę                   | Up to a Regional road at risk (Inc<br>Luas line)<br>National Primary - 5<br>National Secondary - 4<br>Regional - 3<br>Third Class - 2                               | Scor<br>sche<br>rece              | ring considers the percentage of recome option during the 1% AEP event ptors at risk during the 0.1% AEP ev 00%  | eptors protected under the compared to the existing   |        |
|            | c Minimise risk to utility infrastructure   | i) Minimise risk to utility infrastructure   | Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges, etc) at risk from flooding (0.1% AEP Event)   | risk   |   | 10        | 2                   | Minor Road - 1  1 ESB substation at risk with a "low" vulnerability   | sche<br>rece<br>for 1<br>5        |  | compared to the existing<br>ent with a max score of 5 |        |
|            | d Manage Risk to Agricultural Land  | Manage Risk to Agricultural Land   | Area of agricultural land at risk from flooding (based on CORINE data or other)  | No increase on agricultural land at risk   | All agricultural land protected   | 10        | 1                   | No significant area of agricultural land at risk  | sche                              | ing considers the percentage of receive option during the 1% AEP event ptors at risk during the 0.1% AEP ev 00%  | compared to the existing                              |        |
| al         | a Minimise risk to human health and life  | Minimise risk to human health and life of<br>residents   | Number of residential properties at risk from flooding (0.1% AEP Event)  | No additional (or substitution of) residential properties at risk from flooding  | No residential properties at risk from flooding   | 30        | F                   | due to high population  | sche                              | ing considers the percentage of rece<br>eme option during the 1% AEP event<br>ptors at risk during the 0.1% AEP ev<br>00%  | compared to the existing                              |        |
| 1          |   | ii) Minimise risk to high vulnerability properties   | Number of high vulnerability properties (hospitals, residential homes for the sick, elderly, infirm and children) at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) vulnerable properties at risk from flooding   | No vulnerable properties at risk from flooding  | 10        |                     | No high vulnerability properties at risk during the 1% AEP event  | Scor                              | ring considers the percentage of rece<br>eme option during the 1% AEP event<br>ptors at risk during the 0.1% AEP ev  | compared to the existing                              |        |
|            | b Minimise risk to community  | i) Minimise risk to social infrastructure  | Number of high value soical infrastructural assets (first responders, govt buildings) at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) high value social<br>infrastructural assets at risk from flooding   | No high value social infrastructural assetts at risk from flooding  | 5         |                     | no first reponders, no major govt offices at risk during the 1% AEP event   | Scor                              | ring considers the percentage of rece<br>eme option during the 1% AEP event<br>ptors at risk during the 0.1% AEP ev  | compared to the existing                              |        |
|            |   | ii) Minimise risk to local employment  | Number of non-residential properties (fire stations, Garda stations) at risk from flooding (0.1% AEP Event)  | No additional (or substitution of) non-residential properties at risk from flooding  | No non-residential properties at risk from flooding   | 10        |                     | high density of commerical activity   | sche                              | ing considers the percentage of rece<br>eme option during the 1% AEP event<br>ptors at risk during the 0.1% AEP ev<br>00%  | compared to the existing                              |        |
|            | c Minimise risk to flood-sensitive social amenity sites   | i) Minimise risk to flood-sensitive social amenity sites   | Number of amenity sites at risk from flooding (0.1% AEP Event)   | No additional (or substitution of) amenity sites at risk from flooding   | No amenity sites at risk from flooding  | 5         | 2                   | 1 community centre, 2 sports<br>club/leisure centre and playing fields<br>at risk   | sche                              | ing considers the percentage of rece<br>eme option during the 1% AEP event<br>ptors at risk during the 0.1% AEP ev<br>00%  | compared to the existing                              |        |
| ironmental | a Support the objectives of the WFD   | Prevent deterioration in status, and if possible<br>contribute to the achievement of good<br>ecological status / potential of water-bodies   | Ecological status of water bodies  | Provide no constraint associated with flood risk<br>management options to the achievement of good<br>status/potential  | Significant contribution of flood risk management options to<br>the achievement of good status/potential  | 10        | F                   | WFD objectives must be achieved in<br>all water bodies so this objective<br>should always have the maximum<br>local weighting                                       | catc<br>and                       | uction in flooding will reduce input of<br>hment which could have benefits for<br>geomorphological effects can negat<br>is. potential for intermittent transport | water status. Hydrological<br>ively impact on water   |        |
|            | b Minimise the risk to potential sources of environmental pollution   | Minimise the risk to potential sources of<br>environmental pollution   |  | No additional (or substitution of) potential pollution sources<br>at risk from flooding due to the implementation of the flood<br>risk management option   |   | 10        |                     | No receptors in 1% AEP flood extent   |                                   | eves basic target in that no additiona   |   |        |
|            | c Support the objectives of the<br>Habitats Directive   | Avoid damage to, and where possible<br>enhance, European protected Natura 2000<br>sites  | Reported conservation status of Natura 2000 sites relating to flood risk management  | due to the implementation of the flood risk management option  | due to the implementation of the flood risk management option   | 10        | 1                   | No receptors in 1% AEP flood extent,<br>AA has screened out any impacts   | Dod<br>0                          | eves basic target in that no additiona<br>der AA concluded no impacts n that   | catchment   |        |
|            | d Avoid damage to, and where possible enhance, the flora and fauna of the catchment   | <ul> <li>i) Avoid loss/damage to, and where possible<br/>enhance, nationally protected sites of nature<br/>conservation importance i.e. (p)NHA,<br/>Ramsar</li> </ul>              | Reported conservation status of designated sites relating to flood risk management   | No deterioration in conservation status of sites due to the<br>implementation of the flood risk management option  | Improvement in conservation status of sites due to the<br>implementation of the flood risk management option  |           |                     | No receptors in 1% AEP flood extent   | Achi                              | eves basic target in that no additiona   | I receptors are affected                              |        |
|            | -   |  | Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ("target species")   | protected species and other known species of conservation  | No loss of suitable habitat supporting legally protected<br>species and other known species of conservation concern<br>due to the implementation of the flood risk management<br>option | 2.5       | 1                   | Local habitats and species of interest including grassland, woodland and trees. Conservation objectives in development plans  | O Achi                            | eves basic target in that no receptors   | s are affected  |        |
|            | e Protect, and where possible enhance, fisheries resource within the catchment  | Maintain existing, and where possible create<br>new, fisheries habitat including the<br>maintenance or improvement of conditions<br>that allow upstream migration for fish species | Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers   | No loss of integrity of fisheries habitat, maintenance of upstream accessibility   | No loss of fisheries habitat, improvement in habitat quality and/or quality, enhanced upstream accessibility  | 2.5       |                     | The river is culverted for long stretches in lower reaches, not suitable for fisheries  | Achi                              | eves basic target in that no receptors   | s are affected  |        |
|            |   | ii) Protect, and where possible enhance, the quality of shellfish waters   | Classification of shellfish waters   | No detertioration in shellfish water quality parameter values<br>due to the implementation of the flood risk management<br>option  |   | 2.5       | 1                   | Nearest shellfish area is<br>geographically remote at the other<br>side of Howth Head   |                                   | eves basic target in that receptors ar<br>nplementation of the option  | e not negatively affected                             |        |
|            | f Protect, and where possible enhance, landscape character and visual amenity within the river                              | amenity  | Compliance with Landscape Character Objectives for the catchment   | Protection of the Landscape Character of the Catchment   | Catchment   | 5         | 4                   | Stretch of river listed in RMP. Landscape objectives outlined in development plans  | land<br>-3                        | s and embankments are likely to har<br>scape and views   |   |        |
|            | g Avoid damage to or loss of features of cultural heritage importance and their setting                                     | Avoid damage to or loss of features of<br>architectural value and their setting  |  | heritage setting as a reuslt of implementation of the option.  | enhanced protection of sites due to the implementation of the option.   | 2.5       | 3                   | Architectural designations and objectives in development plans  | by ir                             | eves basic target in that receptors ar<br>nplementation of the option  |   |        |
|            |   | <ul> <li>ii) Avoid damage to or loss of features of<br/>archaeological value and their setting</li> </ul>  | Number of UNESCO World Heritage Sites (including candidate UNESCO World Heritage Sites), National Monuments including Temporary Preservation Orders and Register of Historic Monuments, Potential National Monuments in Local Authority Ownership where known), and Recorded Archaeological Sites/Monuments (RMP sites) at risk from flooding. | No additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a reuslt of implementation of the option.   | enhanced protection of sites due to the implementation of   | 2-1       |                     | 1x monument in 19% AEP floodplain. Part of catchment is proposed Unesco<br>site. Stretch of river listed in RMP. Archaeological objectives in<br>development plans. |                                   | s protected from flooding but option of<br>tot on archaeological character and u   |   |        |
|            | h Protect soil function   | i) Avoid loss of soil from erosion   | The area of land which is at risk or currently experiencing erosion from flooding  | No increase in the quantity of land at risk from soil erosion  | A reduction in the quantity of land at risk from soil erosion   | 2.5       | 1                   | Urban catchment with walled banks in most places  |                                   | ly urbanised catchment with few gree   | en areas and not much                                 |        |
|            | i Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities         | i) Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities   | Number of flood sensitive environmental receptors at risk during climate change flood events   | No increase in number of environmental receptors at risk during the MRFS   | Reduction in number of environmental receptors at risk during the HEFS  | 5         | ·                   | Number of environmental receptors at risk is the same for the MRFS and the HEFS (1 ACA, 12 SMR)   | All e                             | nvironmental receptors at risk during<br>ected by proposed option SoP  | MRFS and HEFS   |        |

Eastern CFRAM Study Poddle Options Report

## Appendix C Costing of Options

#### **Costing of: Option 1 Hard Defences**

#### **Construction Costs**

#### Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

| Shapefile ID:   | ilbankinents base | a on previous e | onemes in a | 330Clation With | Height with |              |               |
|-----------------|-------------------|-----------------|-------------|-----------------|-------------|--------------|---------------|
| Option1 HardDef | Туре              | Length          | Height      | Freeboard       |             | Cost £/m2007 | Cost €/m 2013 |
| 9PE_Opt1_01     | Embankment        | 90.88           | 0.35        | 0.50            | 0.85        | 12,832.76    | 19,723.95     |
| 9PE Opt1 02     | Wall              | 100.00          | 1.06        | 0.30            | 1.36        | 134,407.51   | 206,584.34    |
| 9PE_Opt1_04     | Wall              | 100.00          | 2.21        | 0.30            | 2.51        | 197,724.80   |               |
| 9PE_Opt1_05     | Embankment        | 40.04           | 0.33        | 0.50            | 0.83        | 5,564.21     | 8,552.19      |
| 9PE_Opt1_06     | Wall              | 100.00          | 0.85        | 0.30            | 1.15        | 122,845.22   | 188,813.10    |
| 9PE_Opt1_07     | Wall              | 100.00          | 1.38        | 0.30            | 1.68        | 152,026.23   | 233,664.32    |
| 9PE Opt1 08     | Embankment        | 100.00          | 0.29        | 0.50            | 0.79        | 13,338.41    | 20,501.14     |
| 9PE_Opt1_09     | Wall              | 100.00          | 0.64        | 0.30            | 0.94        | 111,282.93   | <u> </u>      |
| 9PE_Opt1_10     | Wall              | 100.00          | 0.64        | 0.30            | 0.94        | 111,282.93   | · ·           |
| 9PE_Opt1_11     | Embankment        | 40.81           | 0.10        | 0.50            | 0.60        | 4,447.07     | 6,835.15      |
| 9PE_Opt1_12     | Wall              | 100.00          | 0.45        | 0.30            | 0.55        | 89,810.11    | 138,038.14    |
| 9PE_Opt1_13     | Wall              | 37.83           | 0.07        | 0.30            | 0.46        | 32,100.59    | 49,338.60     |
| 9PE_Opt1_14     | Wall              | 100.00          | 0.77        | 0.30            | 1.07        | 118,440.54   | 182,043.10    |
| 9PE_Opt1_15     | Wall              | 100.00          | 0.72        | 0.30            | 1.02        | 115,687.61   | 177,811.86    |
| 9PE_Opt1_16     | Wall              | 21.55           | 0.21        | 0.30            | 0.51        | 18,879.47    | 29,017.75     |
| 9PE_Opt1_17     | Wall              | 100.00          | 0.37        | 0.30            | 0.67        | 96,417.13    | 148,193.13    |
| 9PE_Opt1_18     | Wall              | 26.15           | 0.00        | 0.30            | 0.30        | 19,885.89    | 30,564.62     |
| 9PE_Opt1_19     | Wall              | 100.00          | 0.33        | 0.30            | 0.63        | 94,214.79    | 144,808.13    |
| 9PE_Opt1_20     | Wall              | 100.00          | 0.75        | 0.30            | 1.05        | 117,339.37   | 180,350.61    |
| 9PE_Opt1_21     | Wall              | 100.00          | 0.57        | 0.30            | 0.87        | 107,428.83   | 165,118.12    |
| 9PE_Opt1_22     | Wall              | 100.00          | 0.71        | 0.30            | 1.01        | 115,137.03   | 176,965.61    |
| 9PE_Opt1_23     | Wall              | 19.66           | 0.71        | 0.30            | 1.01        | 22,635.94    |               |
| 9PE_Opt1_24     | Wall              | 100.00          | 0.61        | 0.30            | 0.91        | 109,631.17   | 168,503.11    |
| 9PE_Opt1_25     | Wall              | 96.65           | 0.70        | 0.30            | 1.00        | 110,747.79   | 170,219.36    |
| 9PE_Opt1_26     | Wall              | 100.00          | 0.42        | 0.30            | 0.72        | 99,170.06    | 152,424.38    |
| 9PE_Opt1_27     | Wall              | 100.00          | 0.42        | 0.30            | 0.72        | 99,170.06    |               |
| 9PE_Opt1_28     | Wall              | 26.34           | 0.29        | 0.30            | 0.59        | 24,236.08    | 37,250.85     |
| 9PE_Opt1_29     | Wall              | 100.00          | 3.39        | 0.30            | 3.69        | 262,693.85   | ,             |
| 9PE_Opt1_30     | Wall              | 72.52           | 3.39        | 0.30            | 3.69        | 190,505.58   |               |
| 9PE_Opt1_31     | Wall              | 100.00          | 0.25        | 0.30            | 0.55        | 89,810.11    | 138,038.14    |
| 9PE_Opt1_32     | Wall              | 17.50           | 0.00        | 0.30            | 0.30        | 13,307.96    | 20,454.33     |
| 9PE_Opt1_33     | Wall              | 100.00          | 0.41        | 0.30            | 0.71        | 98,619.47    | 151,578.13    |
| 9PE_Opt1_34     | Wall              | 43.44           | 0.11        | 0.30            | 0.41        | 35,665.07    | 54,817.22     |
| 9PE_Opt1_35     | Wall              | 78.64           | 0.00        | 0.30            | 0.30        | 59,802.17    | 91,915.93     |
| 9PE_Opt1_36     | Embankment        | 36.86           | 0.46        | 0.50            | 0.96        | 5,749.51     | 8,837.00      |
| 9PE_Opt1_37     | Wall              | 131.43          | 1.39        | 0.30            | 1.69        | 32,882.88    | 50,540.98     |
| 9PE_Opt1_38     | Wall              | 62.73           | 0.33        | 0.30            | 0.63        | 59,100.94    | ,             |
| 9PE_Opt1_39     | Wall              | 59.37           | 0.00        | 0.30            | 0.30        | 45,148.20    | 69,392.79     |
|                 |                   |                 |             |                 |             |              | 4,841,504.26  |

#### **Costing of Pumping stations**

4 Pumping stations required to discharge pluvial flooding trapped behind proposed walls Based on Mornington flood alleviation scheme and assuming a 200mm dia storm sewer

| 1 pumping station £ | 100,000.00 |
|---------------------|------------|
| 1 pumping station € | 123000     |
| 4 pumping station € | 492,000.00 |

#### Costing of sealing of manholes

Approximately €1000 per manhole required

| Number of manholes to be sealed | 20        |
|---------------------------------|-----------|
| Cost of sealing manholes €      | 20,000.00 |

#### **Project Whole Life Cost**

| Construction cost   | €5,353,504.26  |
|---|----------------|
|   |                |
| Provision for unmeasured items (20%)  | €1,070,700.85  |
|   |                |
| Provision for optimism bias (60%)   | €3,212,102.55  |
| Maintenance costs (NPV over 50yrs)  | €600,000.00    |
| ivianite nance costs (141 v over soyrs)                                       | €000,000.00    |
| Detailed design (design fees) (6%)  | €321,210.26    |
| Construction supervision (5%)   | €267,675.21    |
| Allowance for archaeolgical and/or environmental monitoring/exploration (21%) | €1,124,235.89  |
| Cost of land acquisition/compensation (12.5%)                                 | €669,188.03    |
| Allowance for art (1%)  | €53,535.04     |
|   |                |
| Project Whole Life Cost   | €12,672,152.10 |

#### Summary

| Total Damage/Benefit    | €17,838,862.00 |
|-------------------------|----------------|
| Total Construction Cost | €5,353,504.26  |
| Project Whole Life Cost | €12,672,152.10 |
| BCR                     | 1.41           |
| MCA score               | 2075           |
| MCA BCR                 | 163.74         |

#### Costing of: Option 2 Hard Defences and Upstream Storage

#### **Construction Costs**

#### Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

| Shapefile ID: Option2 HardDef and |            | ·      |        |           |                |              |              |
|-----------------------------------|------------|--------|--------|-----------|----------------|--------------|--------------|
| Storage                           | Туре       | Length | Height | Freeboard | Height with FB | Cost £/m2007 | Cost €/m2013 |
| H9PE_Opt2_01                      | Wall       | 77.21  | 2.17   | 0.30      | 2.47           | 150,962.89   | 232,029.96   |
| H9PE_Opt2_02                      | Embankment | 40.04  | 0.28   | 0.50      | 0.78           | 5,303.17     | 8,150.97     |
| H9PE_Opt2_03                      | Wall       | 101.92 | 0.76   | 0.30      | 1.06           | 120,153.44   | 184,675.83   |
| H9PE_Opt2_04                      | Wall       | 100.00 | 1.34   | 0.30      | 1.64           | 149,823.89   | 230,279.32   |
| H9PE_Opt2_05                      | Embankment | 105.50 | 0.23   | 0.50      | 0.73           | 13,248.43    | 20,362.84    |
| H9PE_Opt2_06                      | Wall       | 126.83 | 0.55   | 0.30      | 0.85           | 134,855.38   | 207,272.71   |
| H9PE_Opt2_07                      | Wall       | 100.00 | 0.74   | 0.30      | 1.04           | 116,788.78   | 179,504.36   |
| H9PE_Opt2_08                      | Wall       | 100.00 | 0.68   | 0.30      | 0.98           | 113,485.27   | 174,426.86   |
| H9PE_Opt2_09                      | Wall       | 21.55  | 0.18   | 0.30      | 0.48           | 18,523.52    | 28,470.65    |
| H9PE_Opt2_10                      | Wall       | 85.72  | 0.32   | 0.30      | 0.62           | 80,288.96    | 123,404.13   |
| H9PE_Opt2_11                      | Wall       | 129.83 | 0.54   | 0.30      | 0.84           | 137,330.38   | 211,076.79   |
| H9PE_Opt2_12                      | Wall       | 91.98  | 0.32   | 0.30      | 0.62           | 86,152.34    | 132,416.14   |
| H9PE_Opt2_13                      | Wall       | 29.32  | 0.32   | 0.30      | 0.62           | 27,462.34    | 42,209.62    |
| H9PE_Opt2_14                      | Wall       | 19.66  | 0.32   | 0.30      | 0.62           | 18,414.38    | 28,302.91    |
| H9PE_Opt2_15                      | Wall       | 76.85  | 0.38   | 0.30      | 0.68           | 74,519.69    | 114,536.76   |
| H9PE_Opt2_16                      | Wall       | 105.37 | 0.41   | 0.30      | 0.71           | 103,915.34   | 159,717.87   |
| H9PE_Opt2_17                      | Wall       | 171.79 | 1.93   | 0.30      | 2.23           | 313,187.62   | 481,369.38   |
| H9PE_Opt2_18                      | Wall       | 113.22 | 0.37   | 0.30      | 0.67           | 109,163.48   | 167,784.26   |
| H9PE_Opt2_19                      | Embankment | 36.86  | 0.46   | 0.50      | 0.96           | 5,749.51     | 8,837.00     |
| H9PE_Opt2_20                      | Wall       | 73.30  | 0.15   | 0.30      | 0.45           | 61,795.02    | 94,978.95    |
| H9PE_Opt2_21                      | Wall       | 76.31  | 0.28   | 0.30      | 0.58           | 69,794.55    | 107,274.22   |
| H9PE_Opt2_22                      | Wall       | 61.52  | 0.57   | 0.30      | 0.87           | 66,090.22    | 101,580.67   |
| H9PE_Opt2_23                      | Wall       | 44.06  | 0.20   | 0.30      | 0.50           | 38,357.39    | 58,955.32    |
| H9PE_Opt2_24                      | Wall       | 75.89  | 0.50   | 0.30      | 0.80           | 78,602.87    | 120,812.61   |
|                                   |            |        |        |           |                |              | 3,218,430.12 |

#### Costing of storage embankments

| Shapefile ID:<br>Option2 Tymon |            |            |            |             |
|--------------------------------|------------|------------|------------|-------------|
| Storage                        | Туре       | Length (m) | Height (m) | Volume (m2) |
| H9PE_Opt2_Store_01             | Embankment | 23.09      | 0.5        | 51.95       |
| H9PE_Opt2_Store_02             | Embankment | 23.09      | 1.73       | 327.16      |
| H9PE_Opt2_Store_03             | Embankment | 23.09      | 2.19       | 483.93      |
| H9PE_Opt2_Store_04             | Embankment | 23.09      | 2.18       | 480.21      |
| H9PE_Opt2_Store_05             | Embankment | 23.09      | 2.36       | 549.28      |
| H9PE_Opt2_Store_06             | Embankment | 23.09      | 2.52       | 614.45      |
| H9PE_Opt2_Store_07             | Embankment | 23.09      | 2.51       | 610.28      |
| H9PE_Opt2_Store_08             | Embankment | 23.09      | 2.41       | 569.27      |
| H9PE_Opt2_Store_09             | Embankment | 23.09      | 3.35       | 1009.44     |
| H9PE_Opt2_Store_10             | Embankment | 23.09      | 1.49       | 257.00      |
| H9PE_Opt2_Store_11             | Embankment | 37.28      | 1.33       | 346.58      |
| H9PE_Opt2_Store_12             | Embankment | 15.56      | 0.18       | 9.91        |
|                                |            | 283.74     |            | 5,309.45    |

#### EA Flood Risk Management Estimating Guide

Cost per m2 fill volume (£/m2)

| Volume  | 500-5000m2 | 5000-15000m2 | >15000m2 |
|---------|------------|--------------|----------|
| Average | 65         | 46           | 24       |
| Min     | 31         | 29           | 17       |
| Max     | 116        | 53           | 31       |
| Number  | 23         | 8            | 9        |

#### EA Flood Risk Management Estimating Guide

Sheet piling, average depth 10m

|                         | Average cost | Min cost | Max cost |
|-------------------------|--------------|----------|----------|
| Urban < 100m length £/m | 6459         | 2421     | 13342    |
| Urban > 100m length £/m | 2081         | 1271     | 3006     |
| Rural £/m               | 1357         | 300      | 3330     |

| Cost of embankment £/m 2013 | 935,577.40   |
|-----------------------------|--------------|
| Cost of embankment €/m 2013 | 1,437,982,46 |

#### Costing of overflow weir

control structure to regulate the discharge from the flood storage in Tymon Park

| Туре             | fixed weir |
|------------------|------------|
| Width (m approx) | 7          |

#### EA Flood Risk Management Estamating Guide

| Fixed weir - average - £/m   | 6,050.00  |
|------------------------------|-----------|
| Narrow fixed - average - £/m | 29,100.00 |
| Movable weir - average - £/m | 61,100.00 |

| Cost of weir (£ 2007) | 42,350.00 |
|-----------------------|-----------|
| Cost of weir (€ 2013) | 65,091.95 |

#### Costing of sealing of manholes

Approximately €1000 per manhole required

|   | Number of manholes to be sealed | 20     |
|---|---------------------------------|--------|
| ſ | Cost of sealing manholes €      | 20,000 |

#### **Project Whole Life Cost**

| €237,075.23<br>€995,715.95<br>€592,688.07<br>€47,415.05 |
|---|
| €995,715.95   |
| ·   |
| €237,075.23   |
| £237.075.23   |
| 6227.075.22   |
| €284,490.27   |
| 0=0,000.00  |
| €720,000.00   |
| €2,844,902.72   |
| €948,300.91   |
| £0.49.200.01  |
| €4,741,504.53   |
|   |

#### Summary

| Total Damage/Benefit    | €17,838,862.00 |
|-------------------------|----------------|
| Total Construction Cost | €4,741,504.53  |
| Project Whole Life Cost | €11,412,092.72 |
| BCR                     | 1.56           |
| MCA                     | 2640           |
| MCA BCR                 | 231.33         |

#### Costing of: Option 3 Hard Defences and Flow Diversion

#### **Construction Costs**

#### Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

| Shapefile ID:<br>Option3_HardDef |            |        |        |           |                |              |              |
|----------------------------------|------------|--------|--------|-----------|----------------|--------------|--------------|
| & Flow Diversion                 | Туре       | Length | Height | Freeboard | Height with FB | Cost £/m2007 | Cost €/m2013 |
| H9PE_Opt3_01                     | Wall       | 67.35  | 1.78   | 0.30      | 2.08           | 117,222.43   | 180,170.88   |
| H9PE_Opt3_02                     | Embankment | 40.04  | 0.00   | 0.50      | 0.50           | 3,841.54     | 5,904.44     |
| H9PE_Opt3_03                     | Wall       | 48.42  | 0.34   | 0.30      | 0.64           | 45,885.39    | 70,525.85    |
| H9PE_Opt3_04                     | Wall       | 100.00 | 0.87   | 0.30      | 1.17           | 123,946.39   | 190,505.60   |
| H9PE_Opt3_05                     | Embankment | 37.35  | 0.00   | 0.50      | 0.50           | 3,584.49     | 5,509.36     |
| H9PE_Opt3_06                     | Wall       | 52.75  | 0.15   | 0.30      | 0.45           | 44,470.50    | 68,351.15    |
| H9PE_Opt3_07                     | Wall       | 100.00 | 0.57   | 0.30      | 0.87           | 107,428.83   | 165,118.12   |
| H9PE_Opt3_08                     | Wall       | 100.00 | 0.53   | 0.30      | 0.83           | 105,226.49   | 161,733.12   |
| H9PE_Opt3_09                     | Wall       | 21.55  | 0.09   | 0.30      | 0.39           | 17,455.66    | 26,829.35    |
| H9PE_Opt3_10                     | Wall       | 65.58  | 0.06   | 0.30      | 0.36           | 52,037.07    | 79,980.97    |
| H9PE_Opt3_11                     | Wall       | 56.36  | 0.28   | 0.30      | 0.58           | 51,547.91    | 79,229.13    |
| H9PE_Opt3_12                     | Wall       | 91.98  | 0.05   | 0.30      | 0.35           | 72,478.77    | 111,399.87   |
| H9PE_Opt3_13                     | Wall       | 48.66  | 0.26   | 0.30      | 0.56           | 43,969.51    | 67,581.14    |
| H9PE_Opt3_14                     | Wall       | 73.06  | 0.10   | 0.30      | 0.40           | 59,581.40    | 91,576.62    |
| H9PE_Opt3_15                     | Wall       | 89.38  | 0.13   | 0.30      | 0.43           | 74,366.92    | 114,301.95   |
| H9PE_Opt3_16                     | Wall       | 104.75 | 0.42   | 0.30      | 0.72           | 103,880.63   | 159,664.53   |
| H9PE_Opt3_17                     | Wall       | 100.00 | 0.25   | 0.30      | 0.55           | 89,810.11    | 138,038.14   |
| H9PE_Opt3_18                     | Embankment | 36.86  | 0.00   | 0.50      | 0.50           | 3,537.67     | 5,437.40     |
| H9PE_Opt3_19                     | Embankment | 68.07  | 0.86   | 0.50      | 1.36           | 14,134.34    | 21,724.48    |
|                                  |            |        |        |           |                |              | 1,743,582.12 |

#### Costing of flow diversion culvert/channel

Flow diversion can possibly consist of a culvert or an open channel or a combniation of both, therefore the most conservative cost arrangment was ascertained at this stage.

| Length of diversion (m)        | 1072 |
|--------------------------------|------|
| Max amount of open channel (m) | 872  |
| Min amount of culvert (m)      | 200  |
| Size of culvert (m²)           | 1.5  |

#### EA Flood Risk Management Estamating Guide

Culverts (Total costs £,000)

| Length (m) | 1.2 | 2.1 | 4   | 6   |
|------------|-----|-----|-----|-----|
| 10         | 93  | 108 | 130 | 146 |
| 20         | 113 | 132 | 158 | 177 |
| 50         | 146 | 171 | 205 | 230 |
| 100        | 177 | 208 | 250 | 280 |
| 200        | 216 | 253 | 304 | 341 |
| 500        | 280 | 328 | 393 | 441 |
| 1000       | 341 | 399 | 479 | 537 |

| Cost of culvert (200m) (£ 2007)  | 253,000.00 |
|----------------------------------|------------|
| Cost of culvert (200m) (€ 2013)  | 388,861.00 |
| Cost of culvert (1072m) (£ 2007) | 399,000.00 |
| Cost of culvert (1072m) (€ 2013) | 613,263.00 |

#### EA Flood Risk Management Estamating Guide

#### Channels (Cost/m)

| Length | Earth | Hard |
|--------|-------|------|
| 50     | 7200  | 4700 |
| 250    | 1300  | 1200 |
| 500    | 600   | 700  |
| 1000   | 300   | 400  |
| 1500   | 200   | 300  |
| 2000   | 200   | 200  |
| 2500   | 100   | 200  |

| Cost of channel (£ 2007) | 328,569.60 |
|--------------------------|------------|
| Cost of channel (€ 2013) | 505,011.48 |

#### Costing of overflow weir

The structure required to control the flow along the River Poddle and the flow through the flow diversion

| Туре             | fixed weir |
|------------------|------------|
| Width (m approx) | 10         |

#### EA Flood Risk Management Estamating Guide

| Fixed weir - average £/m   | 6,050.00  |
|----------------------------|-----------|
| Narrow fixed - average £/m | 29,100.00 |
| Movable weir - average £/m | 61,100.00 |

| Cost of weir (£ 2007) | 60,500.00 |
|-----------------------|-----------|
| Cost of weir (€ 2013) | 92,988.50 |

#### Costing of sealing of manholes

Approximately €1000 per manhole required

| Number of manholes to be sealed | 20     |
|---------------------------------|--------|
| Cost of sealing manholes €      | 20,000 |

#### **Cost of Dodder mitigation measures**

Adding 50mm on to proposed defences at €50/m

| length of proposed defences (m)  | 4,220   |
|----------------------------------|---------|
| Cost to add 50mm to defences (€) | 211,000 |

| Number of additional properties at risk                   | 518     |
|---|---------|
| Amount assigned to protect individual properties (€/prop) | 1000    |
| Cost of protecting additional properties (€)              | 518,000 |

| Total cost to protect properties on Dodder (€) | 729,000   |
|--|-----------|
| Round up due to uncertainty (€)                | 1,000,000 |

| Total cost (€ 2013) for open channel (872m), culvert (200m) and overflow weir | 3,750,443.09 |
|---|--------------|
| Total cost (€ 2013) for culvert (1072m) and overflow weir                     | 3,469,833.62 |

#### **Project Whole Life Cost**

| Construction cost   | €3,750,443.09 |
|---|---------------|
| Provision for unmeasured items (20%)  | €750,088.62   |
| Provision for unmeasured items (20%)  | €/30,000.02   |
| Provision for optimism bias (60%)   | €2,250,265.85 |
| Maintenance costs (NPV over 50yrs)  | €900,000.00   |
| Detailed design (design fees) (6%)  | €225,026.59   |
| Construction supervision (5%)   | €187,522.15   |
| Allowance for archaeolgical and/or environmental monitoring/exploration (21%) | €787,593.05   |
| Cost of land acquisition/compensation (12.5%)                                 | €468,805.39   |
| allowance for art (1%)  | €37,504.43    |
| Additional study on impact on the Dodder                                      | €100,000.00   |
| Project Whole Life Cost   | €9,457,249.17 |

## Summary

| Damage/Benefit          | €17,838,862.00 |
|-------------------------|----------------|
| Construction cost       | €3,750,443.09  |
| Project Whole Life Cost | €9,457,249.17  |
| BCR                     | 1.89           |
| MCA                     | 1925           |
| MCA BCR                 | 203.55         |

#### Costing of: Option 2 Hard Defences and Upstream Storage with culvert blockages

#### **Construction Costs**

#### Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

| Cost of walls and emba                 | nkments based | on previous scher | nes in associa | tion with RPS |                |                                       |                                       |
|--|---------------|-------------------|----------------|---------------|----------------|---------------------------------------|---------------------------------------|
| Shapefile ID: Option2 HardDef and      |               |                   |                |               |                |                                       |                                       |
| Storage                                | Turno         | Longth            | Hoight         | Freeboard     | Height with FB | Cost £/m2007                          | Cost €/m2013                          |
| H9PE Opt2 01                           | Type<br>Wall  | Length 77.21      | Height<br>2.17 | 0.30          | 2.47           | 150,962.89                            | 232,029.96                            |
| H9PE_Opt2_02                           | Embankment    | 40.04             | 0.28           | 0.50          | 0.78           | 5,303.17                              | 8,150.97                              |
| H9PE Opt2 03                           | Wall          | 101.92            | 0.26           | 0.30          | 1.06           | 120,153.44                            |                                       |
| H9PE Opt2 04                           | Wall          | 100.00            | 1.34           | 0.30          | 1.64           | 149,823.89                            | 230,279.32                            |
| H9PE_Opt2_05                           | Embankment    | 105.50            | 0.23           | 0.50          | 0.73           | 13,248.43                             | 20,362.84                             |
| H9PE Opt2 06                           | Wall          | 126.83            | 0.23           |               | 0.75           | · · · · · · · · · · · · · · · · · · · | 207,272.71                            |
|  |               |                   |                | 0.30          |                | 134,855.38                            |                                       |
| H9PE_Opt2_07                           | Wall          | 100.00            | 0.74           | 0.30          | 1.04           | 116,788.78                            | 179,504.36                            |
| H9PE_Opt2_08                           | Wall          | 100.00            | 0.68           | 0.30          | 0.98           | 113,485.27                            | 174,426.86                            |
| H9PE_Opt2_09                           | Wall          | 21.55             | 0.18           | 0.30          | 0.48           | 18,523.52                             |                                       |
| H9PE_Opt2_10*                          | Wall          | 85.72             | 1.10           | 0.30          | 1.40           | 117,101.96                            | 179,985.71                            |
| H9PE_Opt2_11                           | Wall          | 129.83            | 0.54           | 0.30          | 0.84           | 137,330.38                            | 211,076.79                            |
| H9PE_Opt2_12                           | Wall          | 91.98             | 0.32           | 0.30          | 0.62           | 86,152.34                             | · · · · · · · · · · · · · · · · · · · |
| H9PE_Opt2_13                           | Wall          | 29.32             | 0.32           | 0.30          | 0.62           | 27,462.34                             | 42,209.62                             |
| H9PE_Opt2_14                           | Wall          | 19.66             | 0.32           | 0.30          | 0.62           | 18,414.38                             | 28,302.91                             |
| H9PE_Opt2_15                           | Wall          | 76.85             | 0.38           | 0.30          | 0.68           | 74,519.69                             | 114,536.76                            |
| H9PE_Opt2_16                           | Wall          | 105.37            | 0.41           | 0.30          | 0.71           | 103,915.34                            | 159,717.87                            |
| H9PE_Opt2_17*                          | Wall          | 45.28             | 2.06           | 0.30          | 2.36           | 85,790.21                             | 131,859.56                            |
| H9PE_Opt2_18                           | Wall          | 113.22            | 0.37           | 0.30          | 0.67           | 109,163.48                            | 167,784.26                            |
| H9PE_Opt2_19                           | Embankment    | 36.86             | 0.46           | 0.50          | 0.96           | 5,749.51                              | 8,837.00                              |
| H9PE_Opt2_20                           | Wall          | 73.30             | 0.15           | 0.30          | 0.45           | 61,795.02                             | 94,978.95                             |
| H9PE_Opt2_21                           | Wall          | 76.31             | 0.28           | 0.30          | 0.58           | 69,794.55                             | 107,274.22                            |
| H9PE_Opt2_22*                          | Wall          | 27.96             | 3.27           | 0.30          | 3.57           | 71,601.88                             | 110,052.08                            |
| H9PE_Opt2_23*                          | Wall          | 78.00             | 0.77           | 0.30          | 1.07           | 92,383.62                             | 141,993.62                            |
| H9PE_Opt2_24                           | Wall          | 75.89             | 0.50           | 0.30          | 0.80           | 78,602.87                             | 120,812.61                            |
| H9PE_Opt2_HCross_1                     | Wall          | 49.00             | 0.59           | 0.30          | 0.89           | 53,179.70                             | 81,737.20                             |
| H9PE_Opt2_HCross_2                     | Wall          | 81.60             | 1.67           | 0.30          | 1.97           | 137,082.45                            | 210,695.73                            |
| H9PE_Opt2_HCross_3                     | Wall          | 26.40             | 2.09           | 0.30          | 2.39           | 50,455.09                             | 77,549.48                             |
| H9PE_Opt2_HCross_4                     | Wall          | 153.20            | 1.49           | 0.30          | 1.79           | 242,182.65                            | 372,234.73                            |
| H9PE Opt2 HCross 5                     | Wall          | 89.60             | 2.16           | 0.30          | 2.46           | 174,694.80                            | 268,505.90                            |
| H9PE_Opt2_MArgus_1                     | Embankment    | 35.01             | 0.41           | 0.50          | 0.91           | 5,233.97                              | 8,044.62                              |
| H9PE_Opt2_MArgus_2                     |               | 22.11             | 1.00           | 0.30          | 1.30           | 28,987.09                             |                                       |
| H9PE Opt2 MArgus 3                     |               | 17.36             | 1.68           | 0.30          | 1.98           | 29,259.20                             | 44,971.39                             |
| H9PE Opt2 MArgus 4                     |               | 87.95             | 1.33           | 0.30          | 1.63           | 131,285.87                            | 201,786.39                            |
| H9PE Opt2 MArgus 5                     |               | 69.70             | 0.52           | 0.30          | 0.82           | 72,959.11                             | 112,138.15                            |
| H9PE_Opt2_MArgus_6                     |               | 48.38             | 0.68           | 0.30          | 0.98           | 54,904.17                             | 84,387.71                             |
| H9PE Opt2 MArgus 7                     |               | 54.53             | 0.65           | 0.30          | 0.95           | 60,982.82                             | 93,730.59                             |
| H9PE Opt2 SDrive 1                     |               | 100.40            | 2.81           | 0.30          | 3.11           | 231,682.95                            | 356,096.69                            |
| H9PE_Opt2_SDrive_2                     |               | 99.73             | 1.56           | 0.30          | 1.86           | 161,499.53                            |                                       |
| H9PE Opt2 PPark 1                      | Wall          | 39.01             | 2.75           | 0.30          | 3.05           | 88,730.74                             |                                       |
| H9PE_Opt2_PPark_2                      | Wall          | 46.15             | 2.12           | 0.30          | 2.42           | 88,963.14                             |                                       |
|  | Wall          | 127.73            | 1.33           | 0.30          | 1.63           | 190,666.79                            | 293,054.86                            |
| H9PE_Opt2_PPark_3<br>H9PE_Opt2_PPark_4 | Wall          | 73.44             | 0.62           | 0.30          | 0.92           | 80,917.48                             | 124,370.17                            |
| H9PE_Opt2_PPark_4                      |               | 43.11             | 2.21           |               | 2.51           | · · · · · · · · · · · · · · · · · · · |                                       |
|  | Wall          |                   |                | 0.30          |                | 85,239.16                             | 131,012.59                            |
| H9PE_Opt2_PPark_6                      | Wall          | 60.01             | 1.94           | 0.30          | 2.24           | 109,733.69                            | 168,660.67                            |
| H9PE_Opt2_PPark_7                      | Wall          | 85.44             | 1.13           | 0.30          | 1.43           | 118,130.71                            | 181,566.91                            |
| H9PE_Opt2_PPark_8                      | Wall          | 117.54            | 1.74           | 0.30          | 2.04           | 201,989.31                            | 310,457.57                            |
|  |               |                   |                |               |                |                                       | 6,703,906.40                          |

<sup>\*</sup> lengths and/or heights of original reaches of walls and embankments amended

#### Costing of storage embankments

| Shapefile ID:      |                |            |            |             |  |  |
|--------------------|----------------|------------|------------|-------------|--|--|
| Option2_Tymon_     | Option2_Tymon_ |            |            |             |  |  |
| Storage            | Туре           | Length (m) | Height (m) | Volume (m2) |  |  |
| H9PE_Opt2_Store_01 | Embankment     | 23.09      | 0.5        | 51.95       |  |  |
| H9PE_Opt2_Store_02 | Embankment     | 23.09      | 1.73       | 327.16      |  |  |
| H9PE_Opt2_Store_03 | Embankment     | 23.09      | 2.19       | 483.93      |  |  |
| H9PE_Opt2_Store_04 | Embankment     | 23.09      | 2.18       | 480.21      |  |  |
| H9PE_Opt2_Store_05 | Embankment     | 23.09      | 2.36       | 549.28      |  |  |

| Shapefile ID:<br>Option2_Tymon_<br>Storage | Туре       | Length (m) | Height (m) | Volume (m2) |
|--|------------|------------|------------|-------------|
| H9PE_Opt2_Store_06                         | Embankment | 23.09      | 2.52       | 614.45      |
| H9PE_Opt2_Store_08                         | Embankment | 23.09      | 2.41       | 569.27      |
| H9PE_Opt2_Store_09                         | Embankment | 23.09      | 3.35       | 1009.44     |
| H9PE_Opt2_Store_10                         | Embankment | 23.09      | 1.49       | 257.00      |
| H9PE_Opt2_Store_11                         | Embankment | 37.28      | 1.33       | 346.58      |
| H9PE_Opt2_Store_12                         | Embankment | 15.56      | 0.18       | 9.91        |
|  |            | 260.65     |            | 4,699.18    |

#### EA Flood Risk Management Estimating Guide

#### Cost per m2 fill volume (£/m2)

| Volume  | 500-5000m2 | 5000-15000m2 | >15000m2 |
|---------|------------|--------------|----------|
| Average | 65         | 46           | 24       |
| Min     | 31         | 29           | 17       |
| Max     | 116        | 53           | 31       |
| Number  | 23         | 8            | 9        |

#### EA Flood Risk Management Estimating Guide

Sheet piling, average depth 10m

|                         | Average cost | Min cost | Max cost |
|-------------------------|--------------|----------|----------|
| Urban < 100m length £/m | 6459         | 2421     | 13342    |
| Urban > 100m length £/m | 2081         | 1271     | 3006     |
| Rural £/m               | 1357         | 300      | 3330     |

| Cost of embankment £/m 2013 | 847,859.19   |
|-----------------------------|--------------|
| Cost of embankment €/m 2013 | 1,303,159.58 |

#### Costing of overflow weir

control structure to regulate the discharge from the flood storage in Tymon Park

| Туре             | fixed weir |
|------------------|------------|
| Width (m approx) | 7          |

#### EA Flood Risk Management Estamating Guide

| Fixed weir - average - £/m   | 6,050.00  |
|------------------------------|-----------|
| Narrow fixed - average - £/m | 29,100.00 |
| Movable weir - average - £/m | 61,100.00 |

| Cost of weir (£ 2007) | 42,350.00 |
|-----------------------|-----------|
| Cost of weir (€ 2013) | 65.091.95 |

#### Costing of sealing of manholes

Approximately €1000 per manhole required

| Number of manholes to be sealed | 20     |
|---------------------------------|--------|
| Cost of sealing manholes €      | 20,000 |

#### Costing of trash screens

| Trash Screen Harolds Cross (€) | 20,000 |
|--------------------------------|--------|
| Trash Screen Mount Argus (€)   | 20,000 |
| Trash Screen Sundrive (€)      | 20,000 |
| Trash Screen Poddle Park (€)   | 20,000 |
|                                | 80,000 |

#### **Project Whole Life Cost**

|   | 60 472 457 00  |
|---|----------------|
| Construction cost   | €8,172,157.93  |
|   |                |
| Provision for unmeasured items (20%)  | €1,634,431.59  |
|   |                |
| Provision for optimism bias (60%)   | €4,903,294.76  |
|   |                |
| Maintenance costs (NPV over 50yrs)  | €720,000.00    |
|   |                |
| Detailed design (design fees) (6%)  | €490,329.48    |
|   |                |
| Construction supervision (5%)   | €408,607.90    |
|   |                |
| Allowance for archaeolgical and/or environmental monitoring/exploration (21%) | €1,716,153.17  |
|   |                |
| Cost of land acquisition/compensation (12.5%)                                 | €1,021,519.74  |
|   |                |
| allowance for art (1%)  | €81,721.58     |
|   | , , ,          |
| Project Whole Life Cost   | €19,148,216.14 |

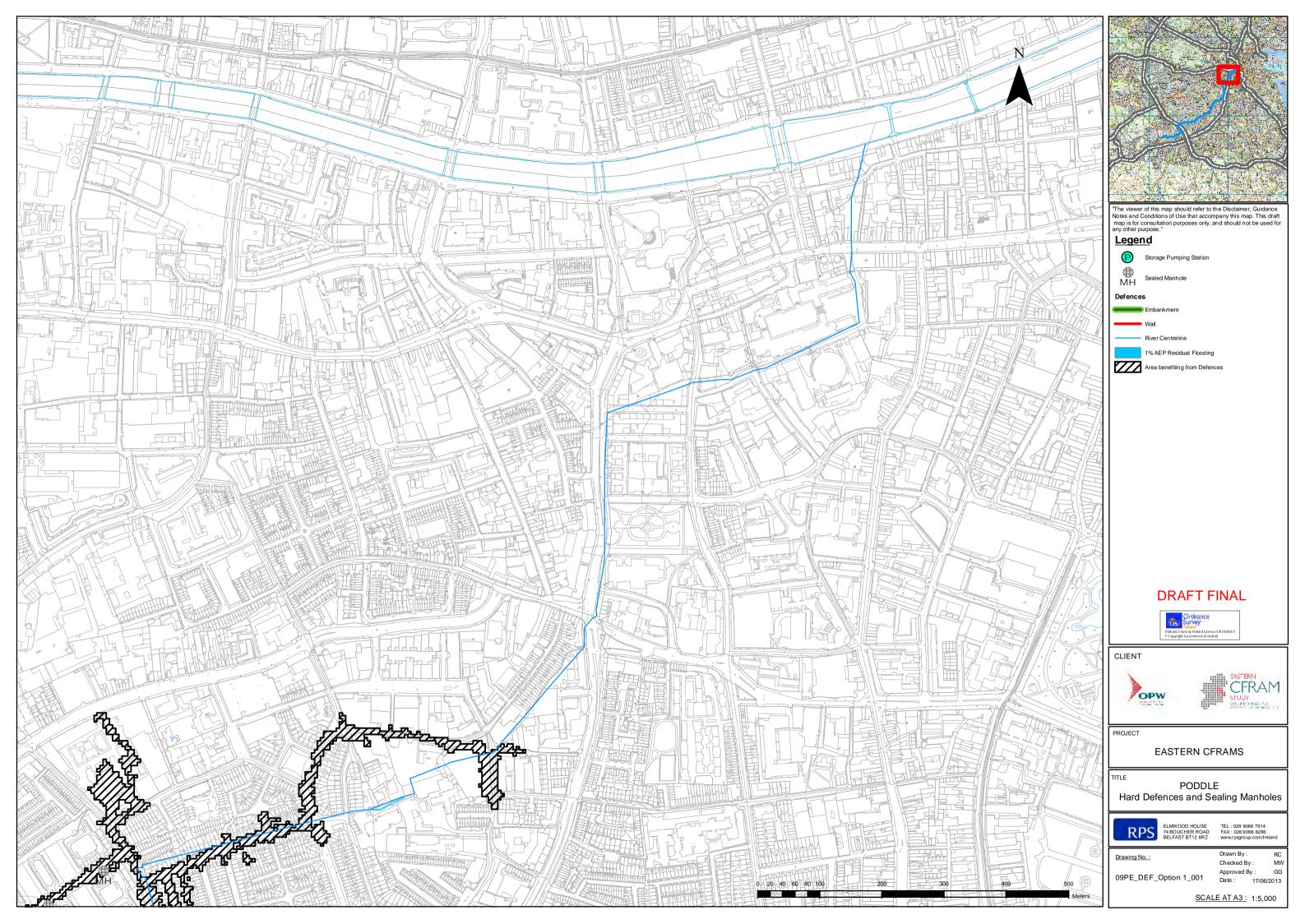
#### Summary

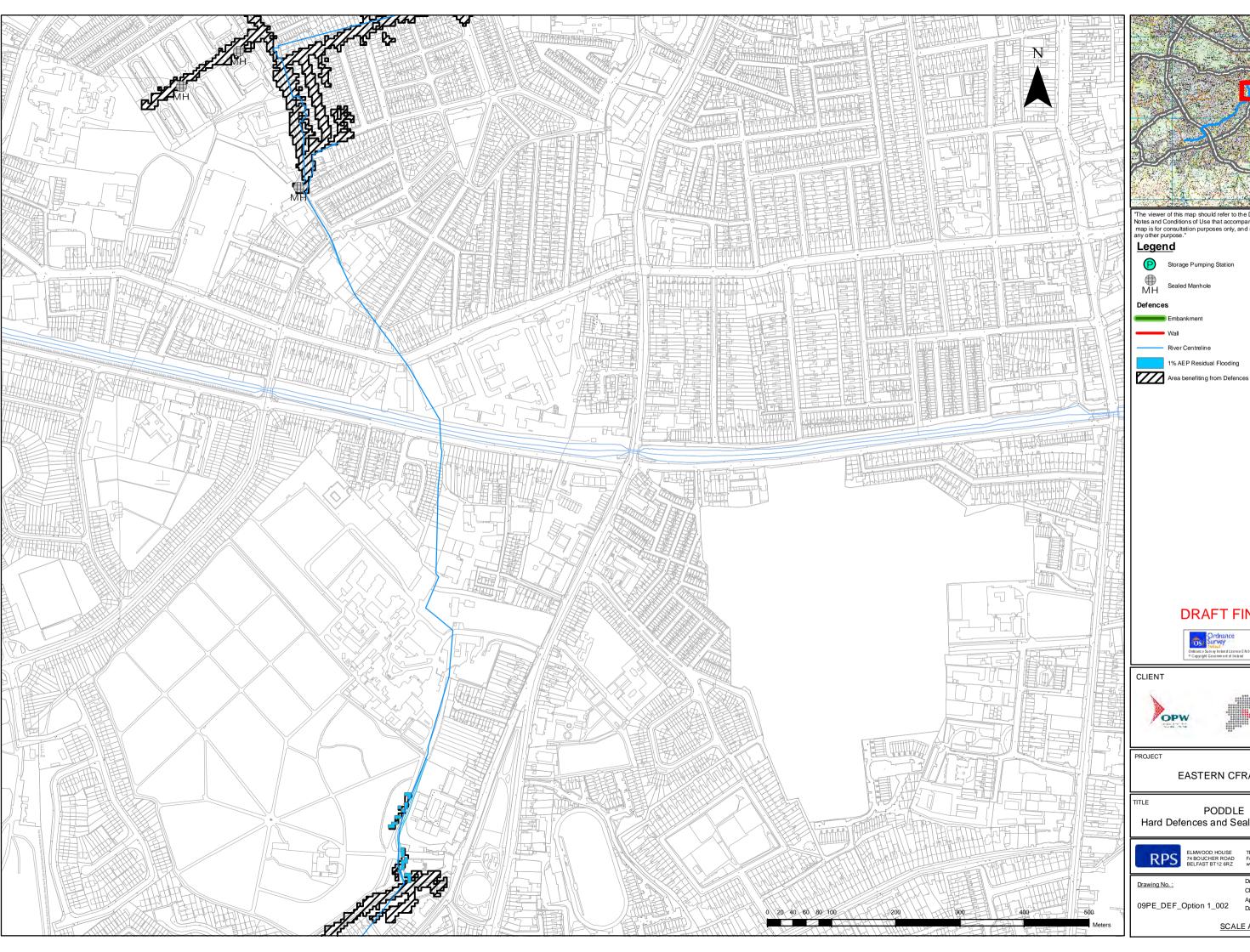
| Total Damage/Benefit    | €39,428,786.00 |
|-------------------------|----------------|
| Total Construction Cost | €8,172,157.93  |
| Project Whole Life Cost | €19,148,216.14 |
| BCR                     | 2.06           |
| MCA                     | 2640           |
| MCA BCR                 | 137.87         |

# Appendix D Flood Defence Maps

Eastern CFRAM Study

Poddle Options Report







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#### 1% AEP Residual Flooding

#### **DRAFT FINAL**



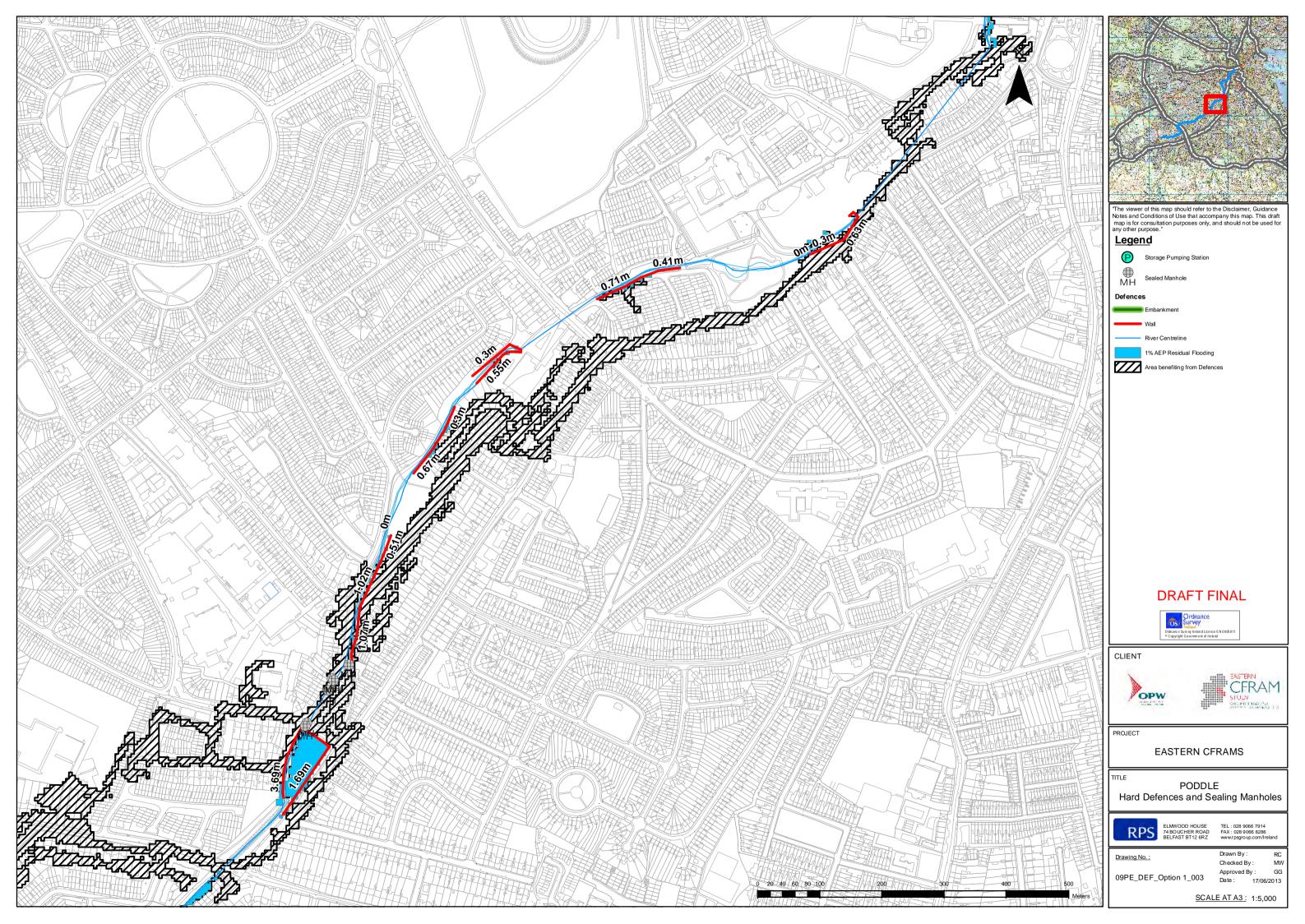


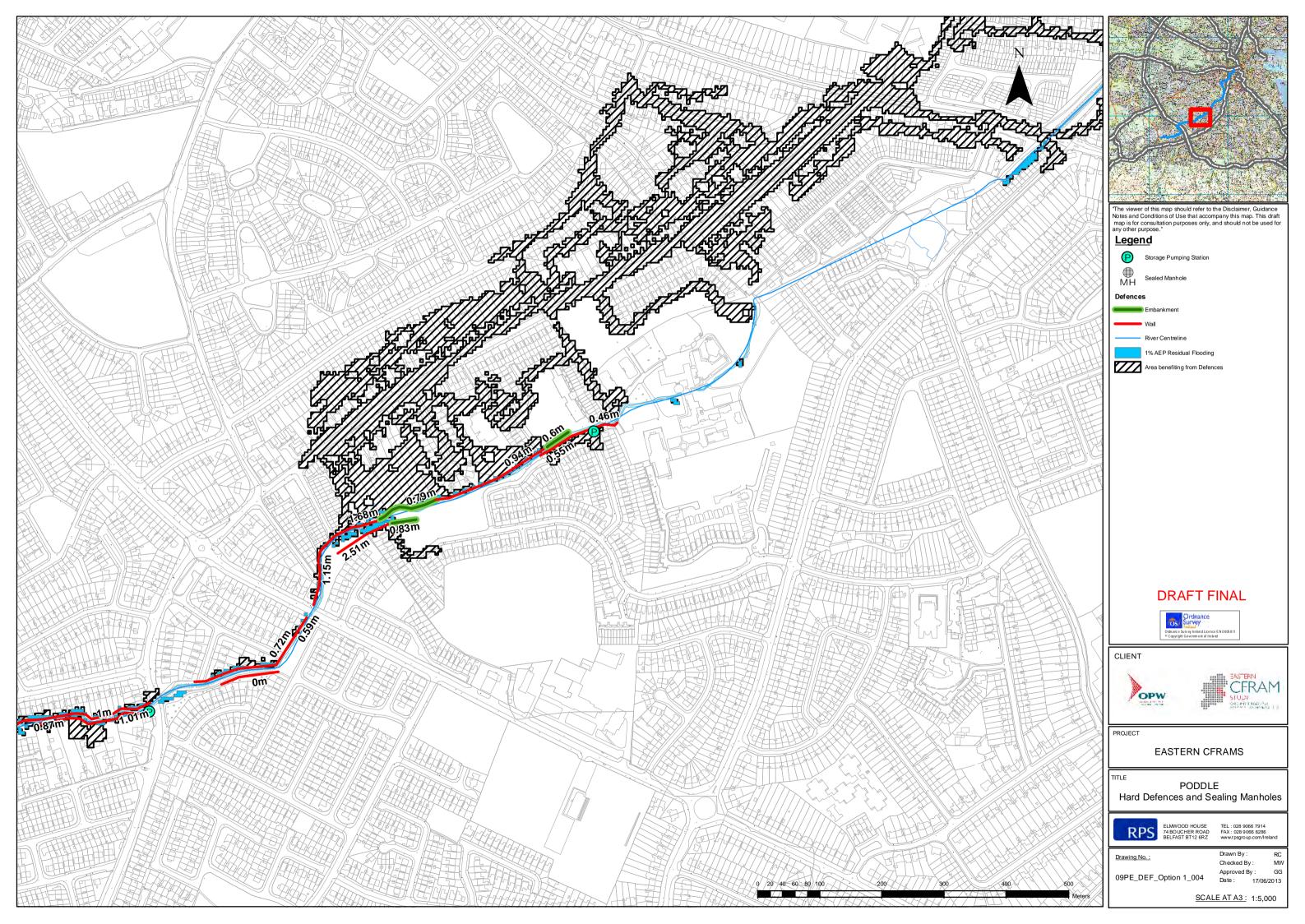
EASTERN CFRAMS

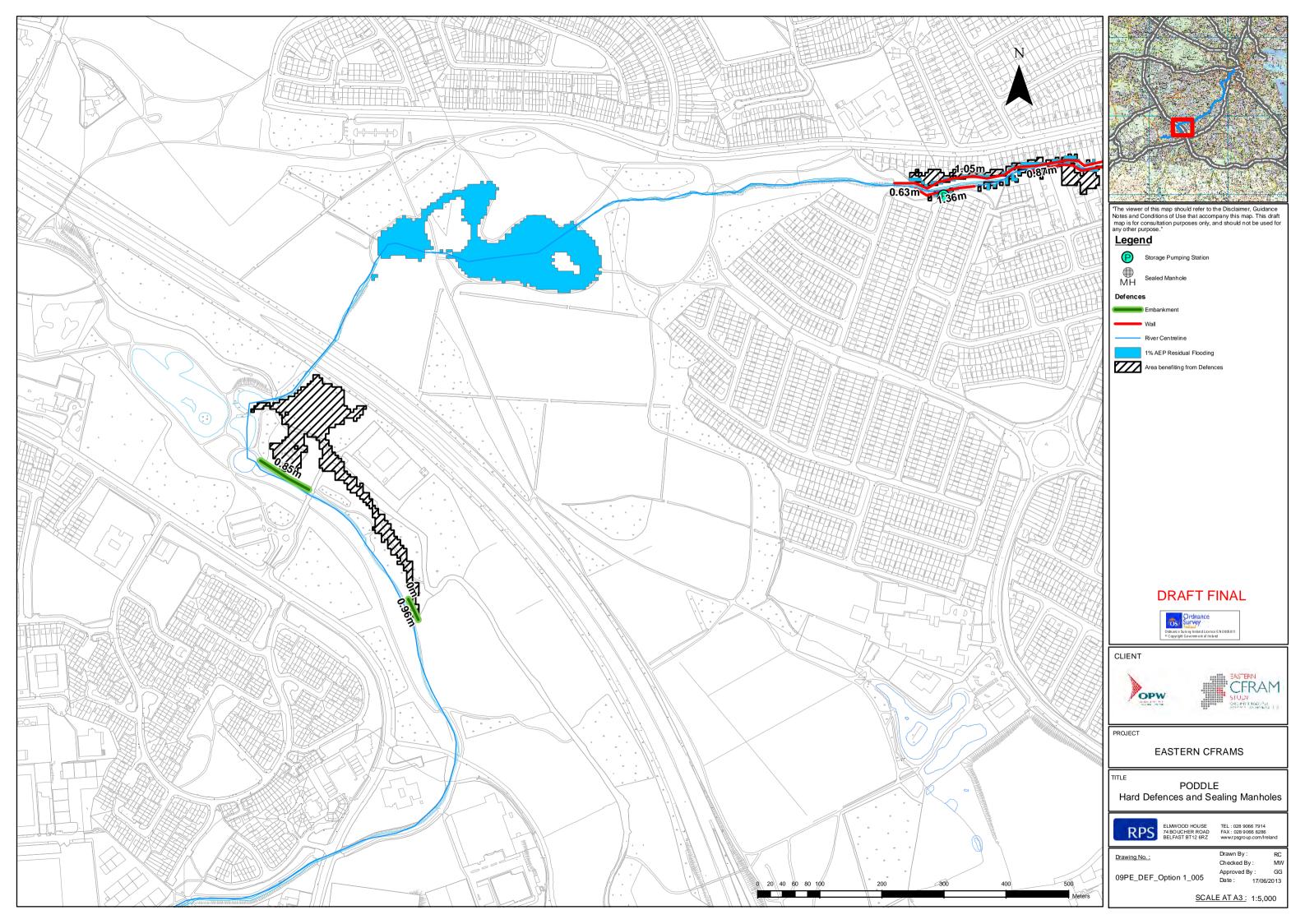
PODDLE Hard Defences and Sealing Manholes

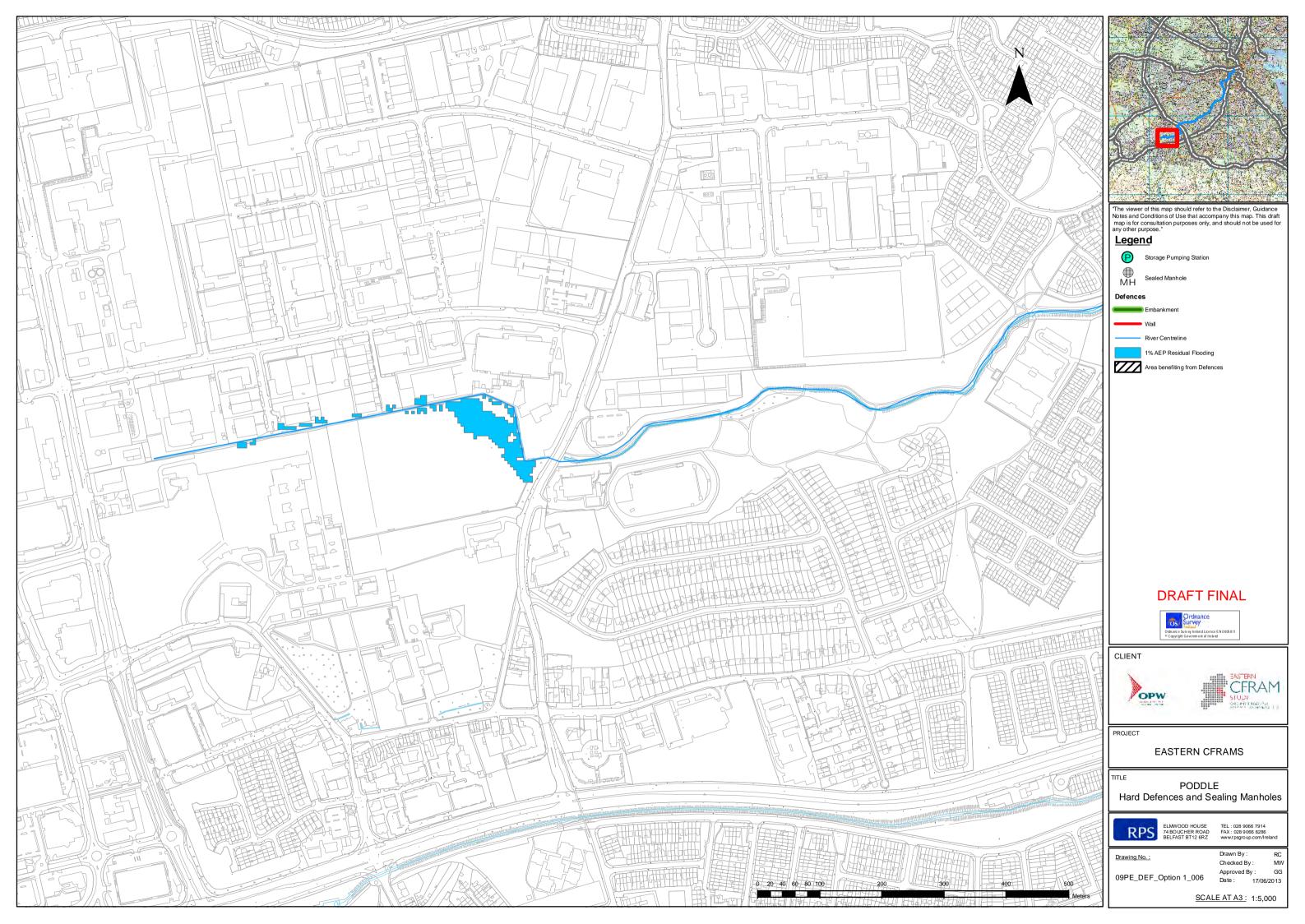
Approved By : Date : 17

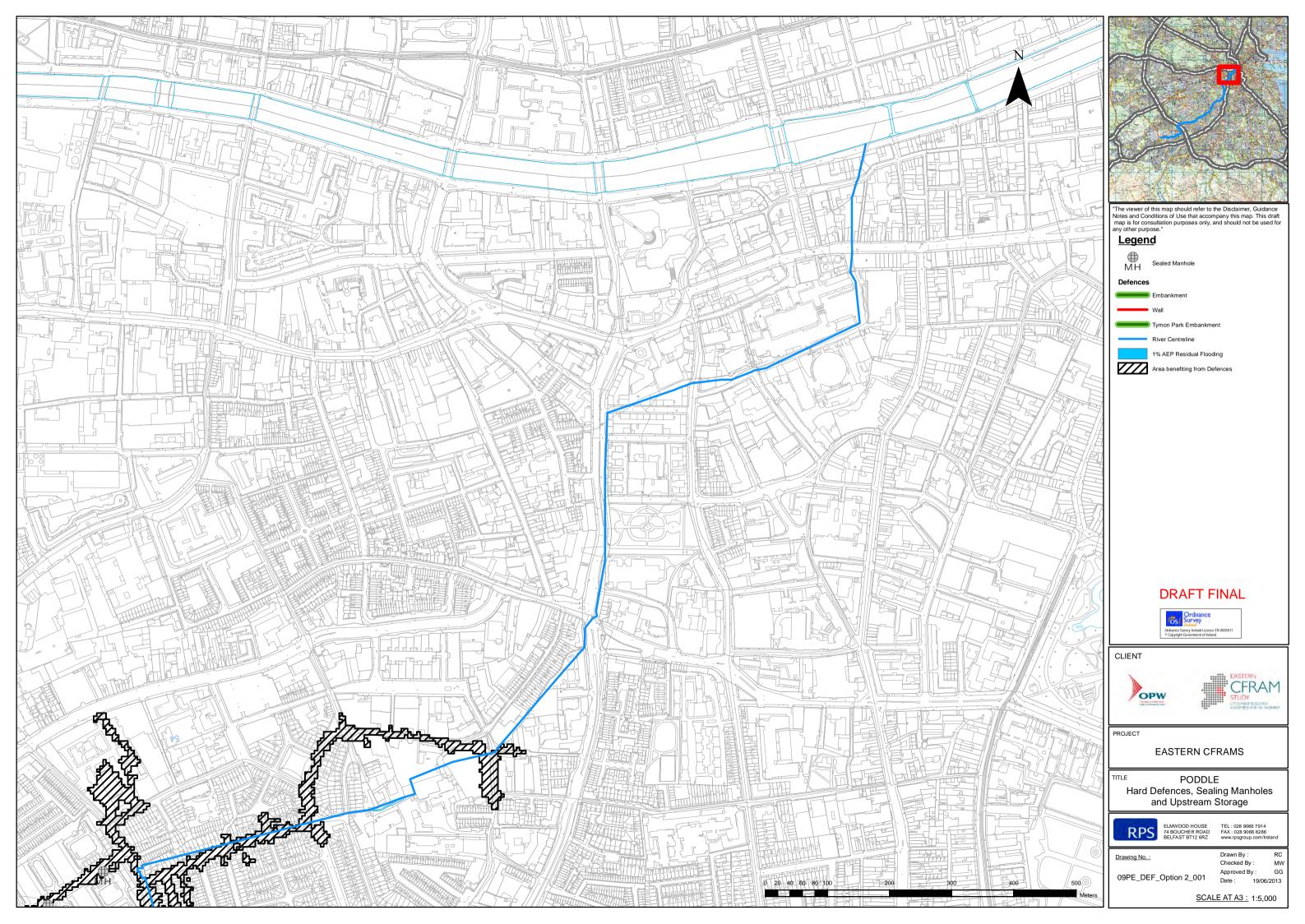
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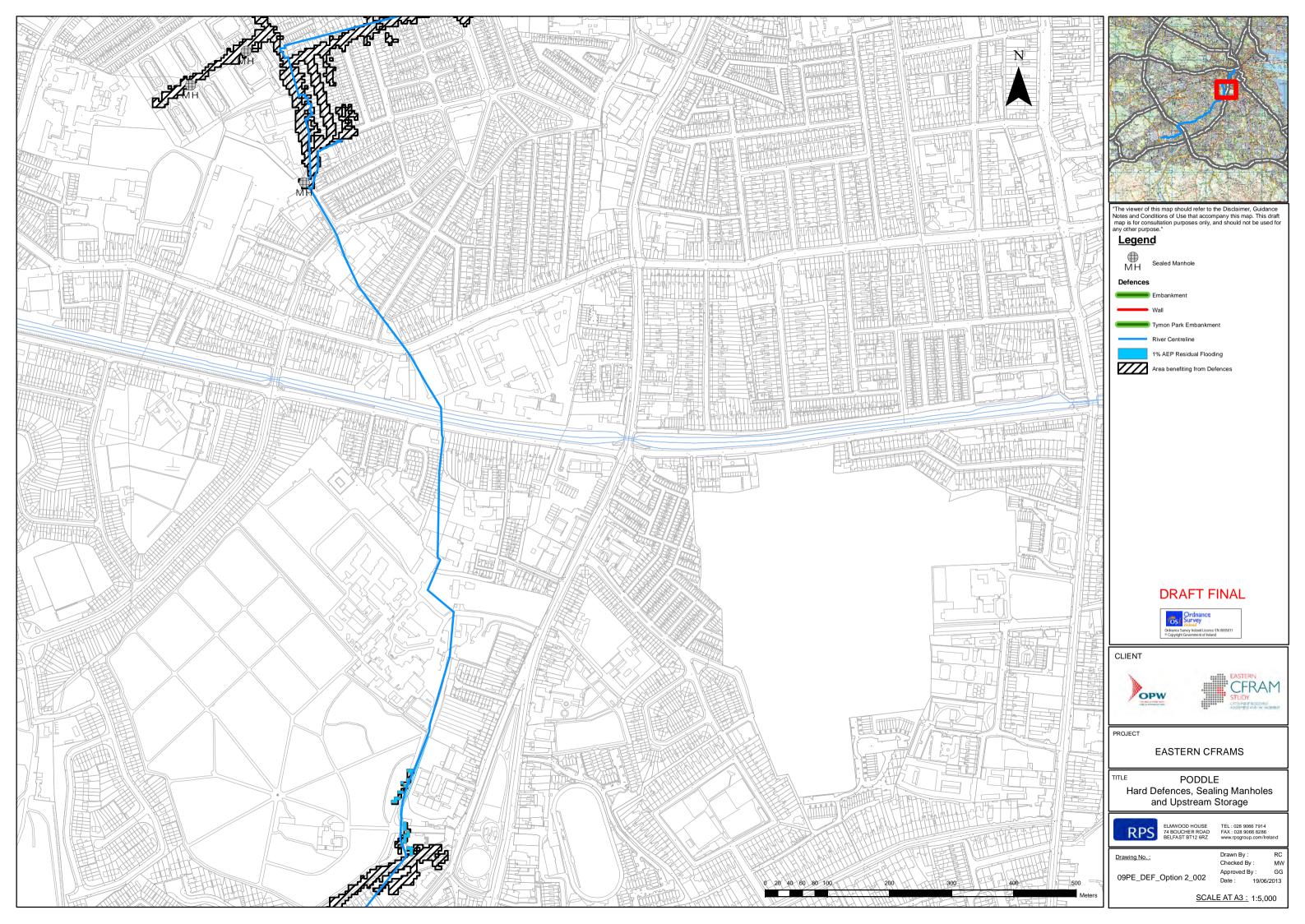


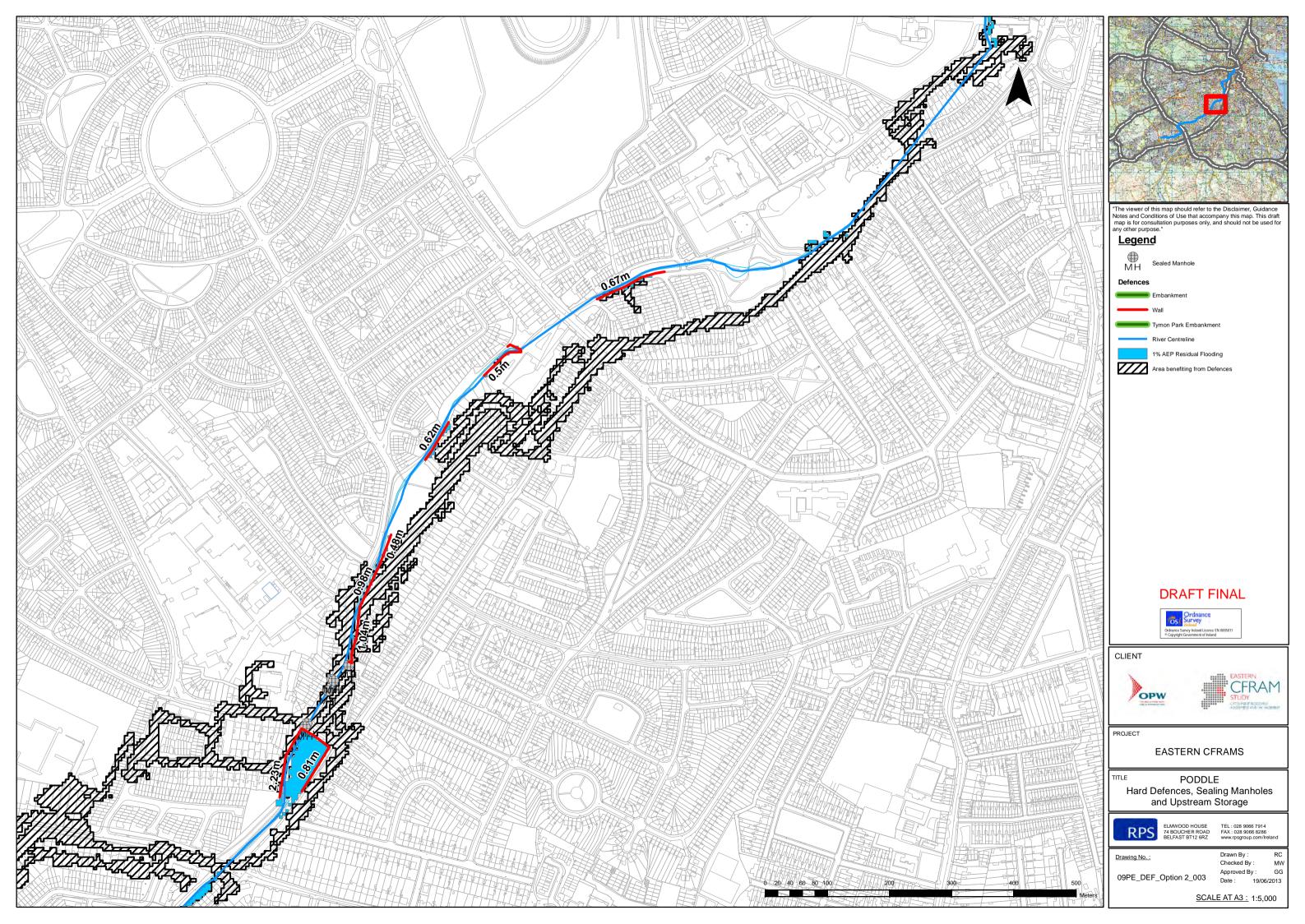


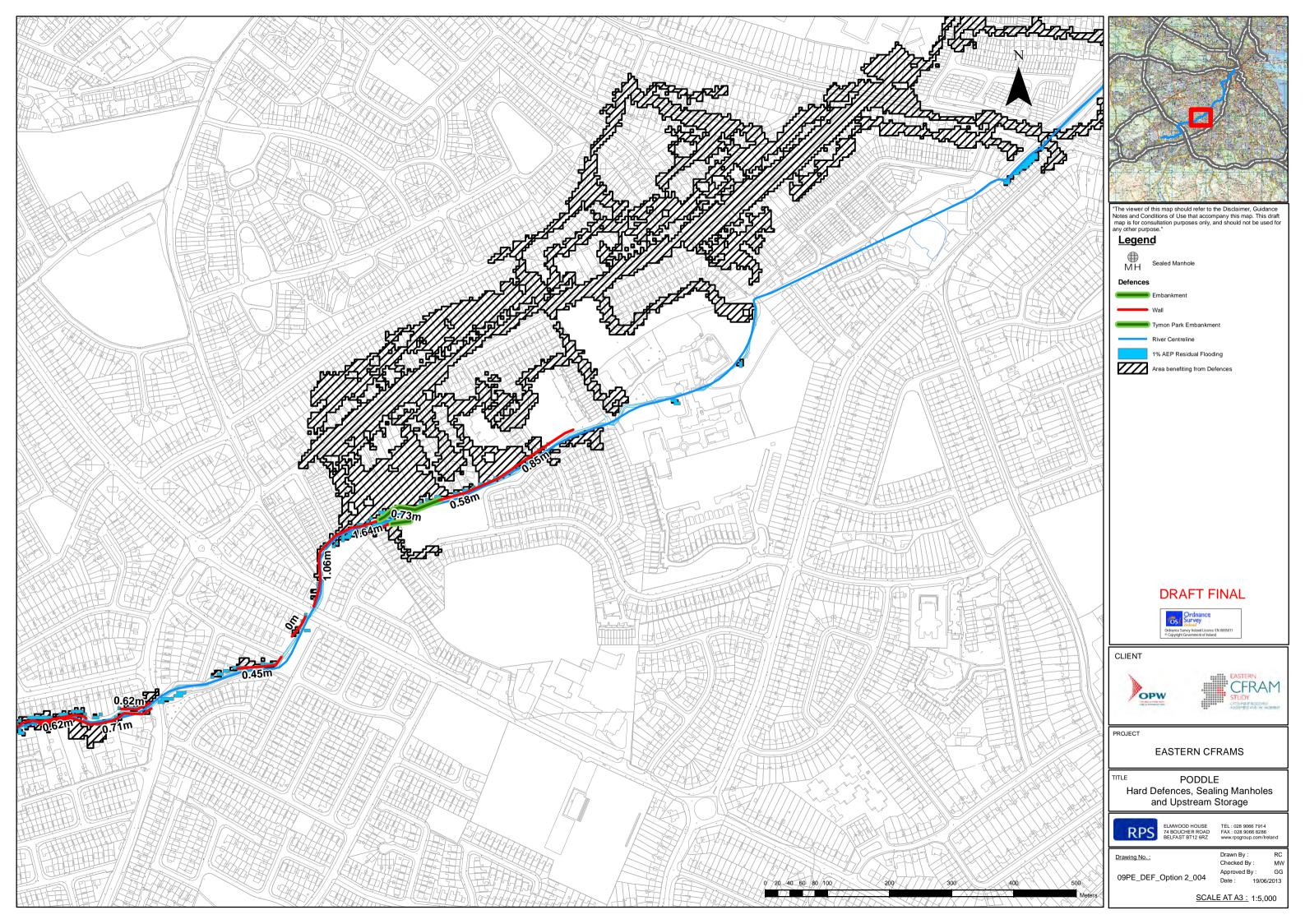


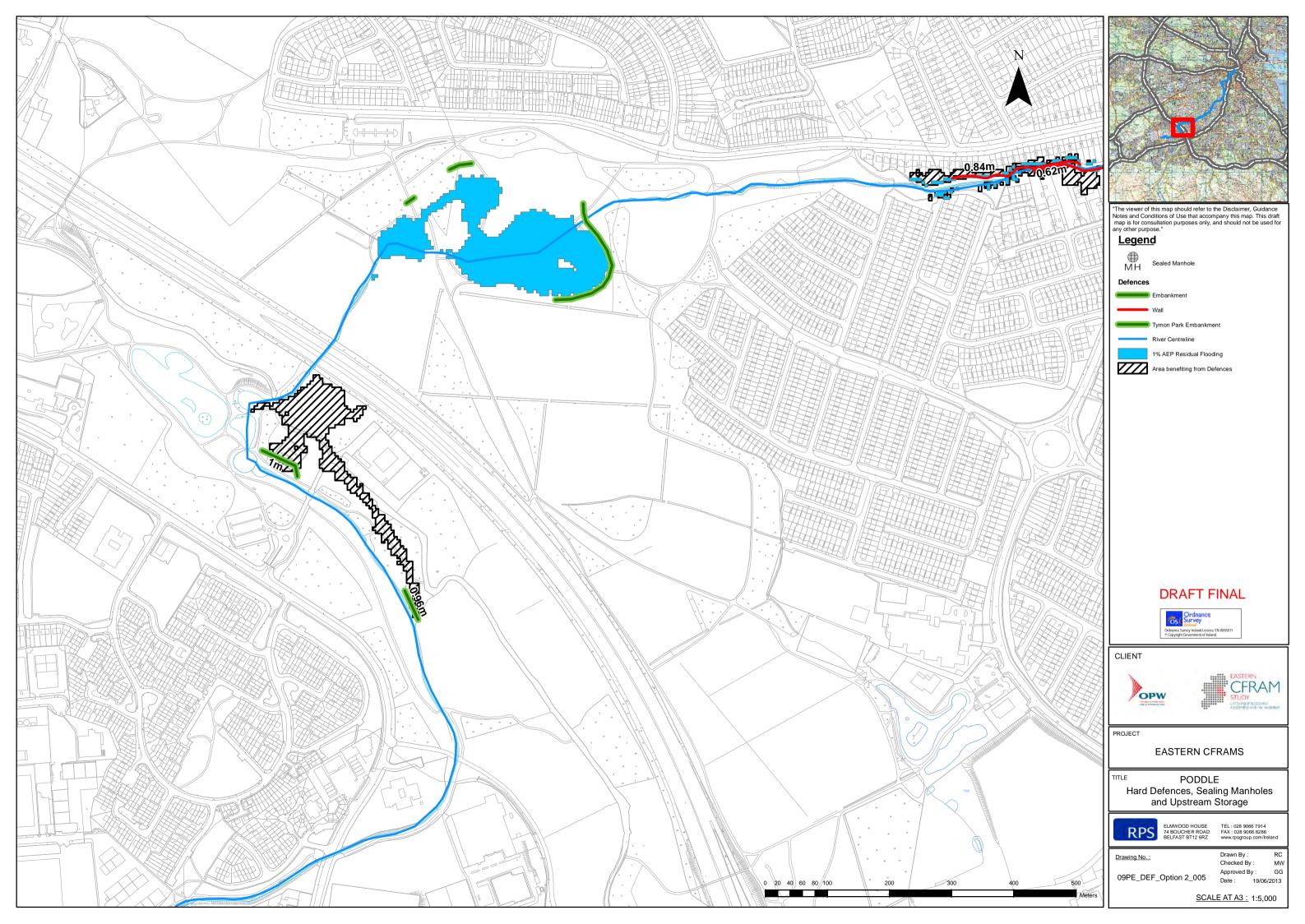


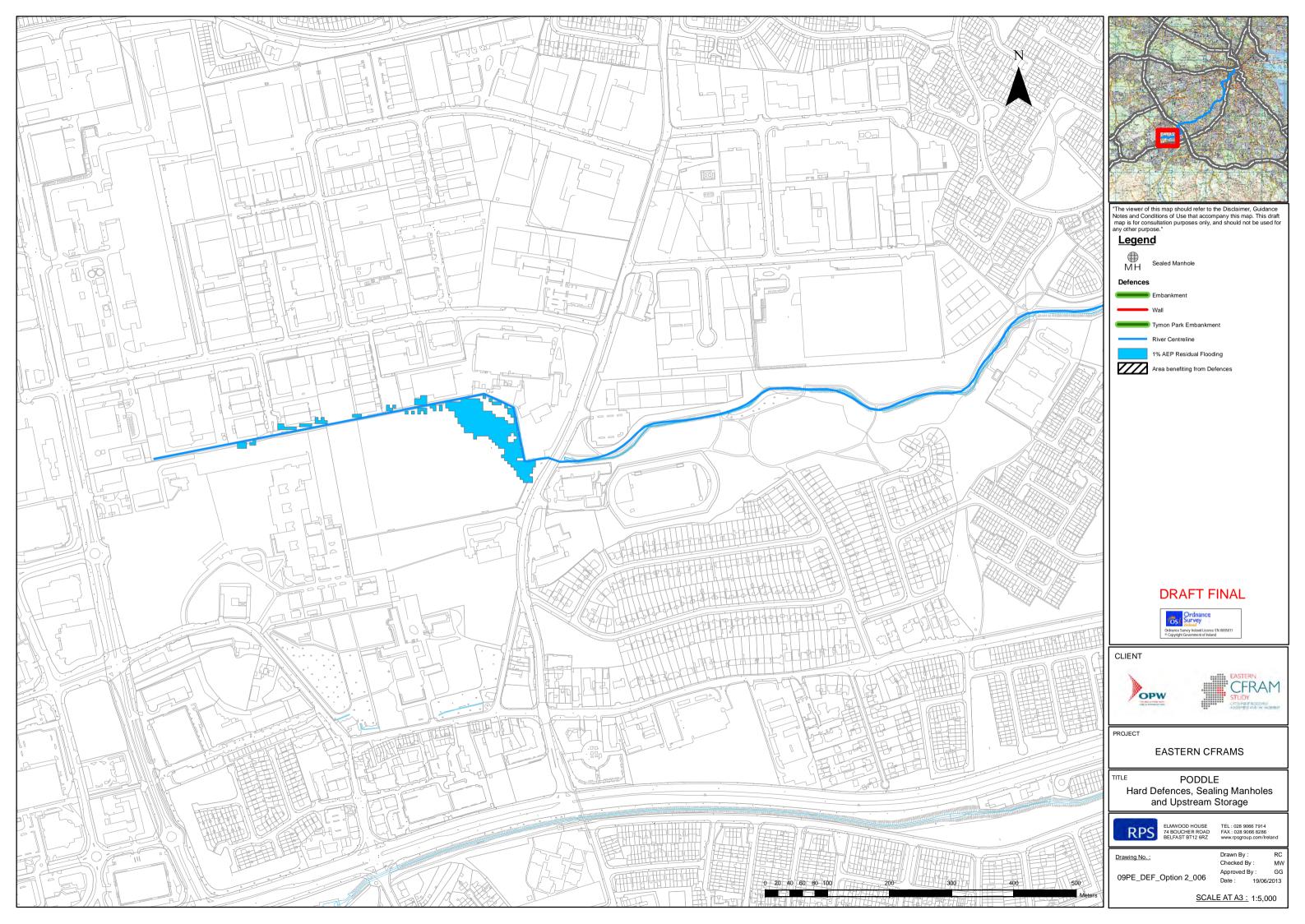


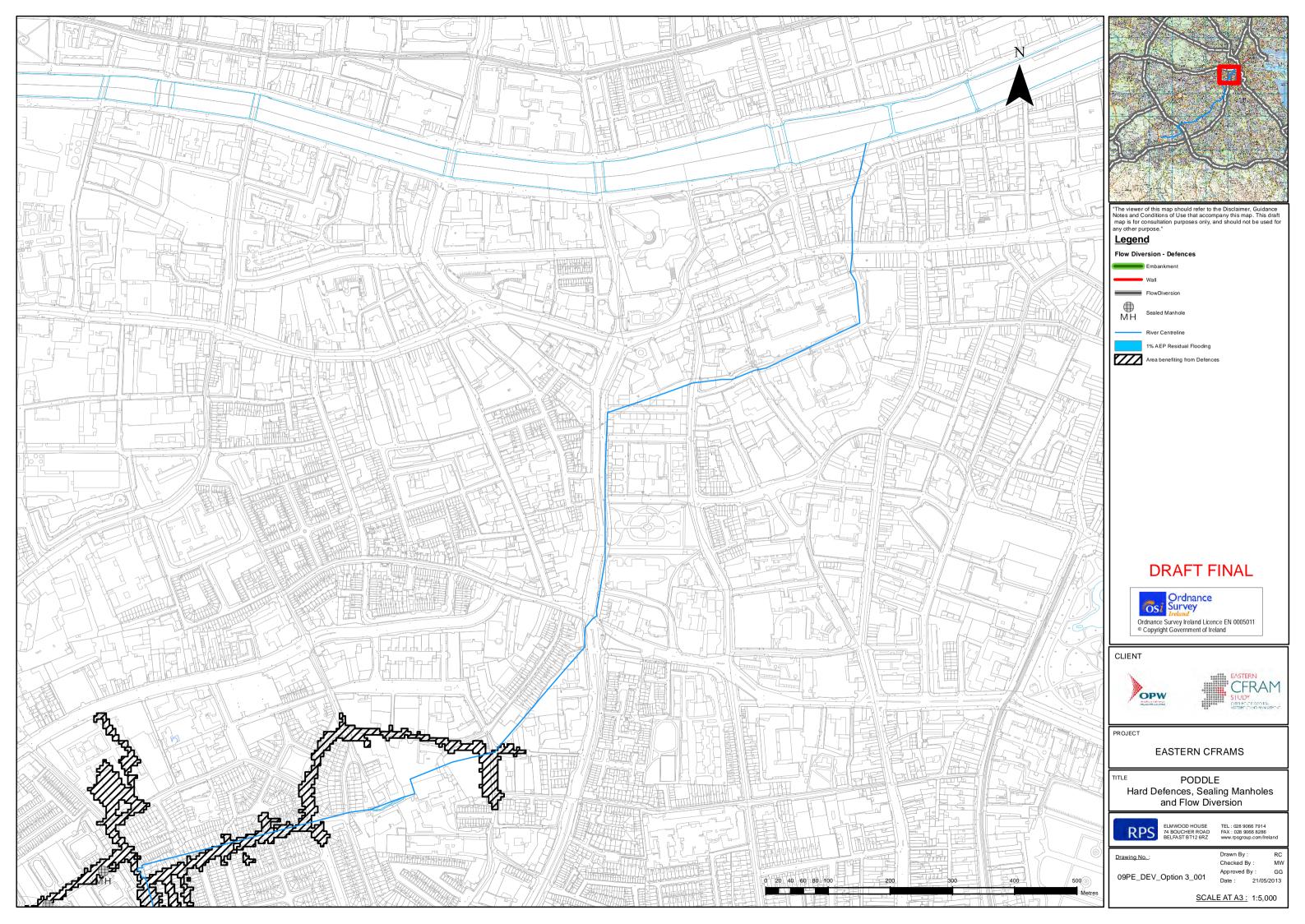


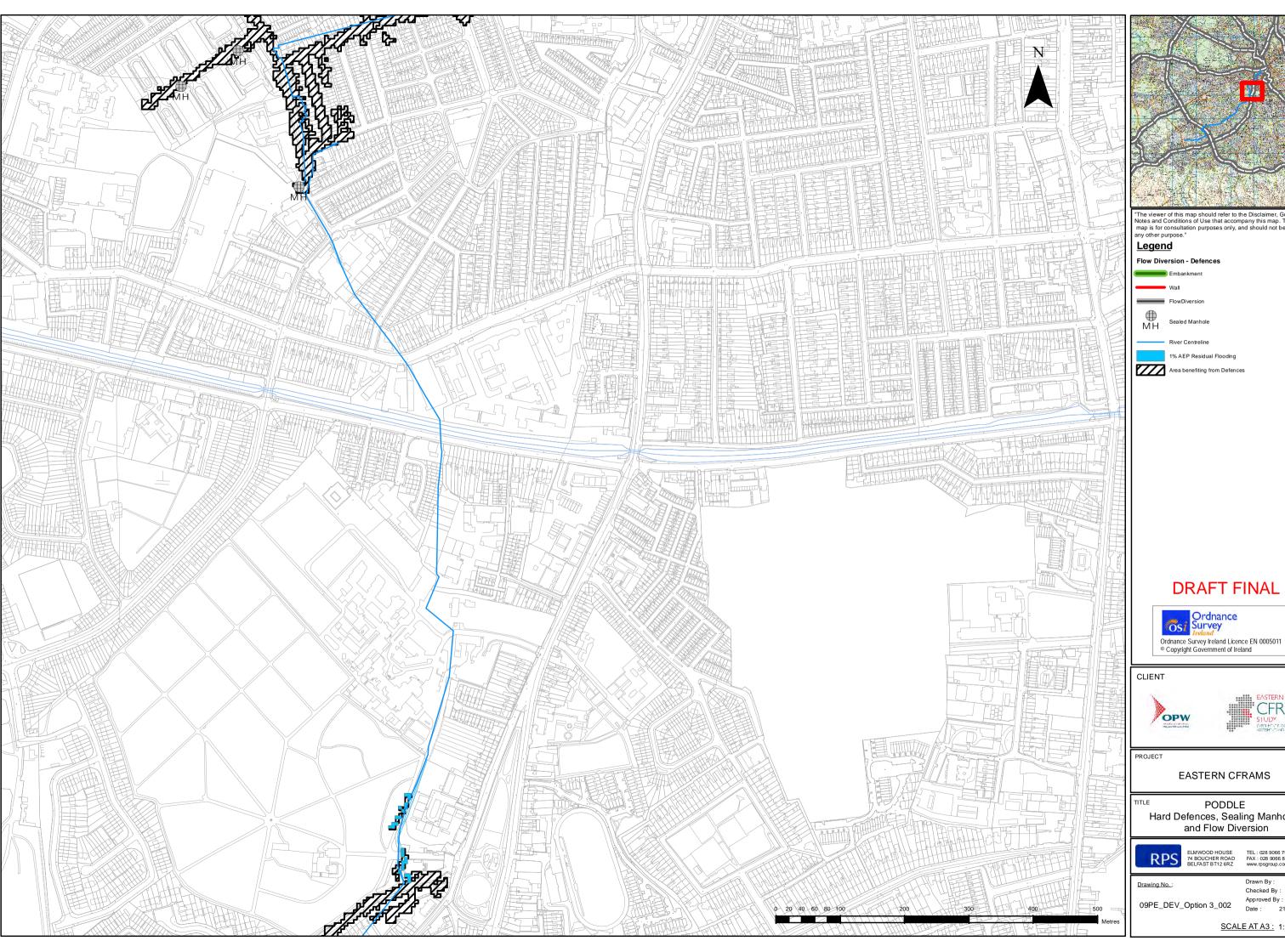














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1% AEP Residual Flooding

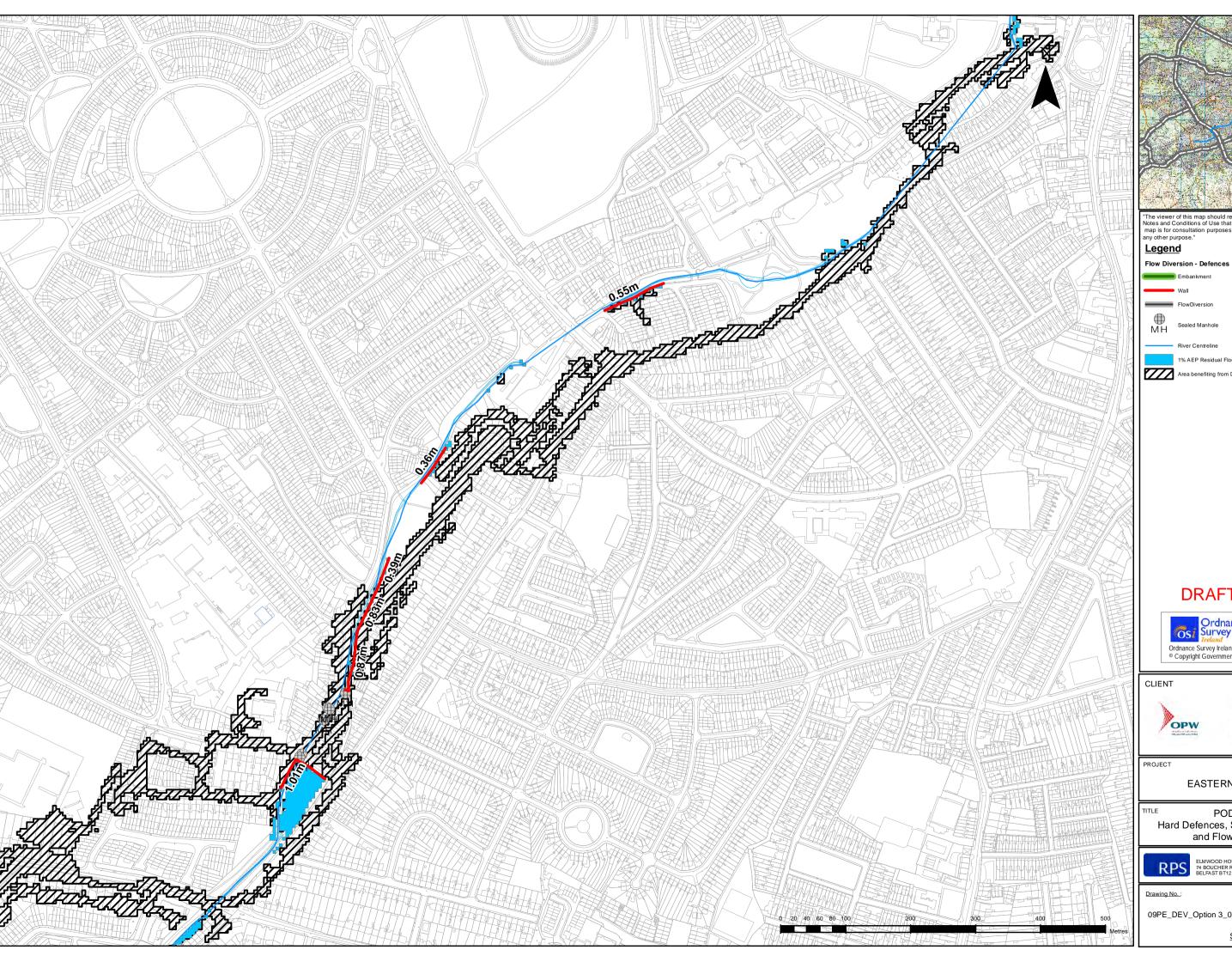




#### EASTERN CFRAMS

PODDLE
Hard Defences, Sealing Manholes

SCALE AT A3: 1:5,000





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1% AEP Residual Flooding

## **DRAFT FINAL**



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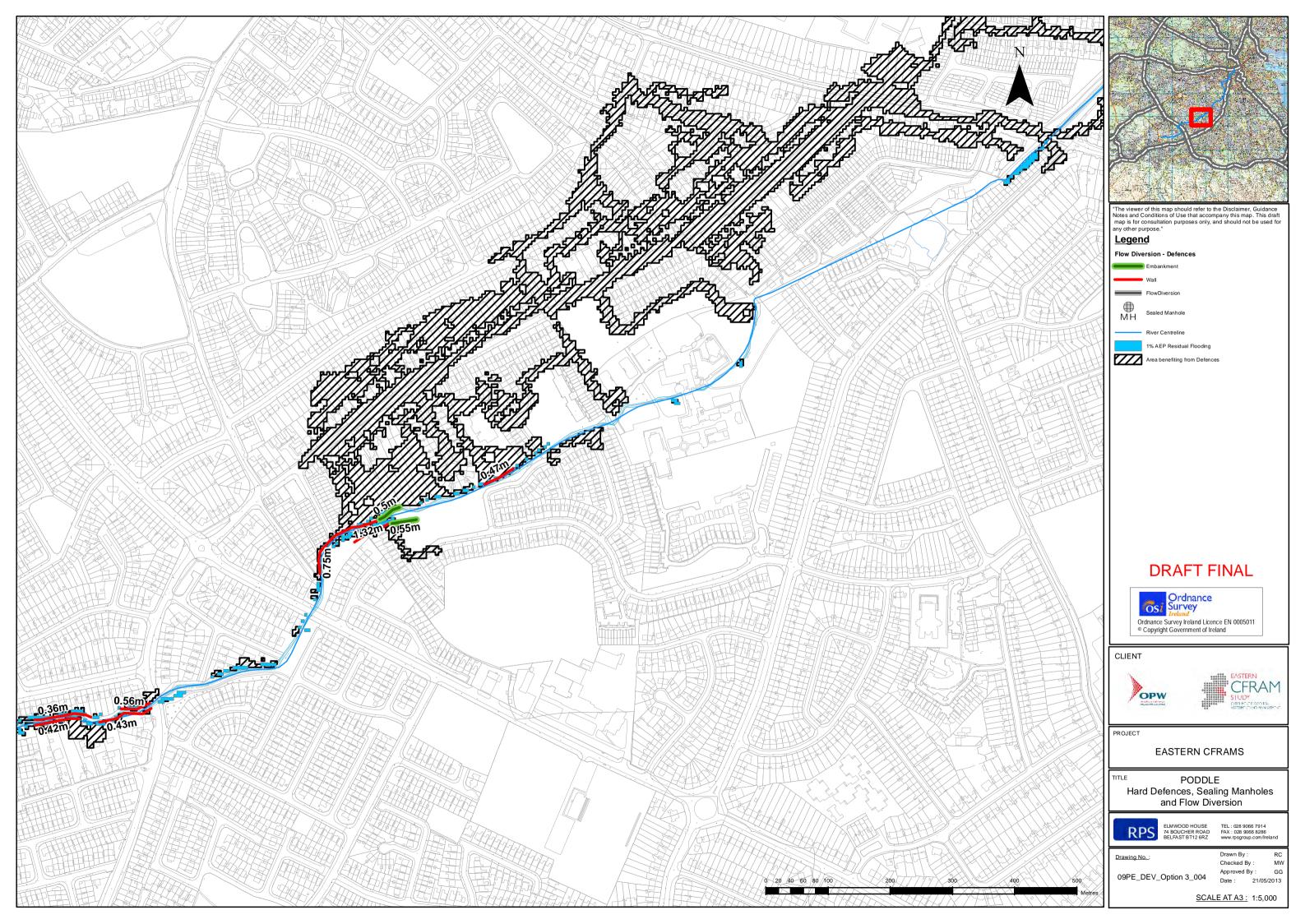


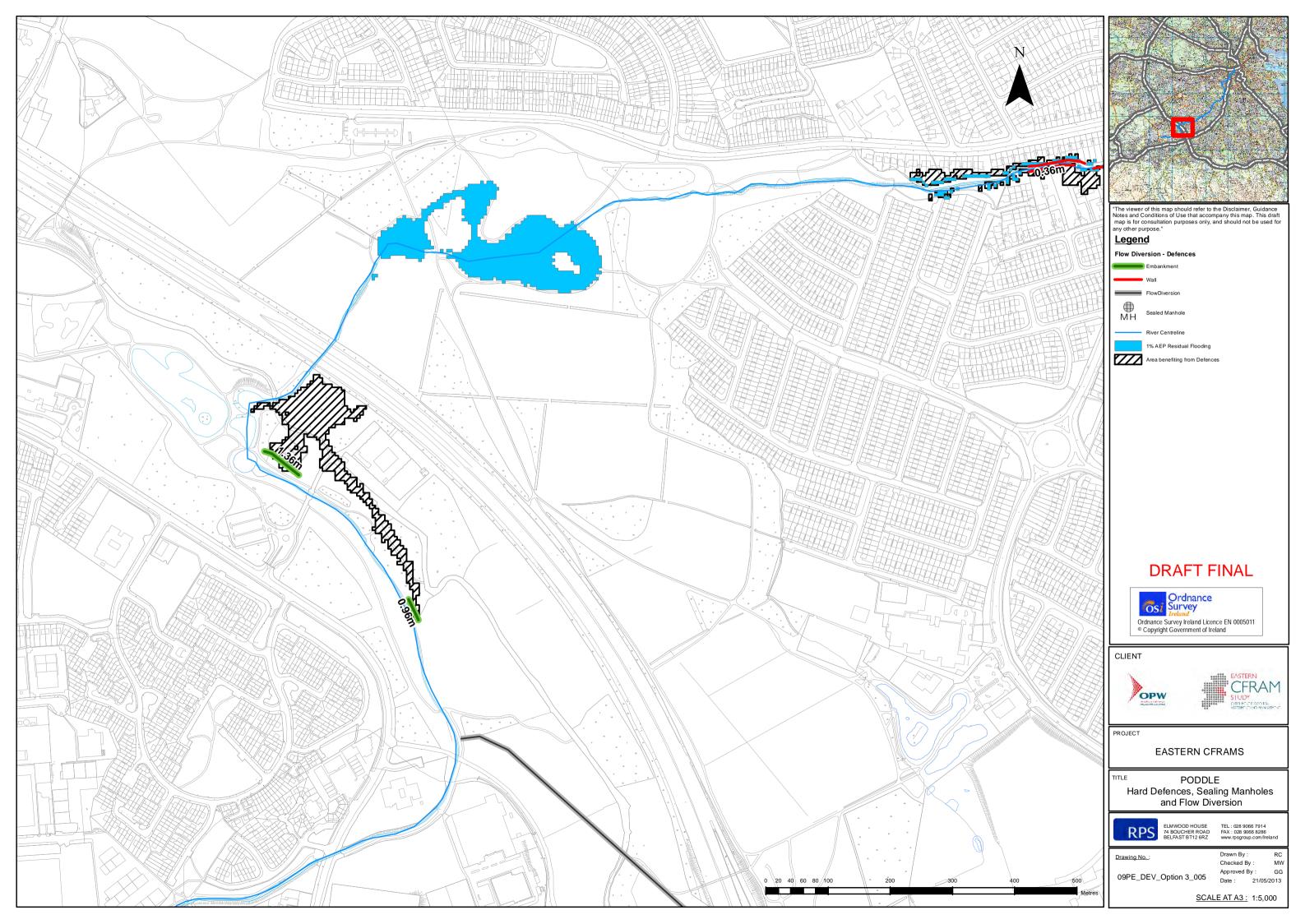
EASTERN CFRAMS

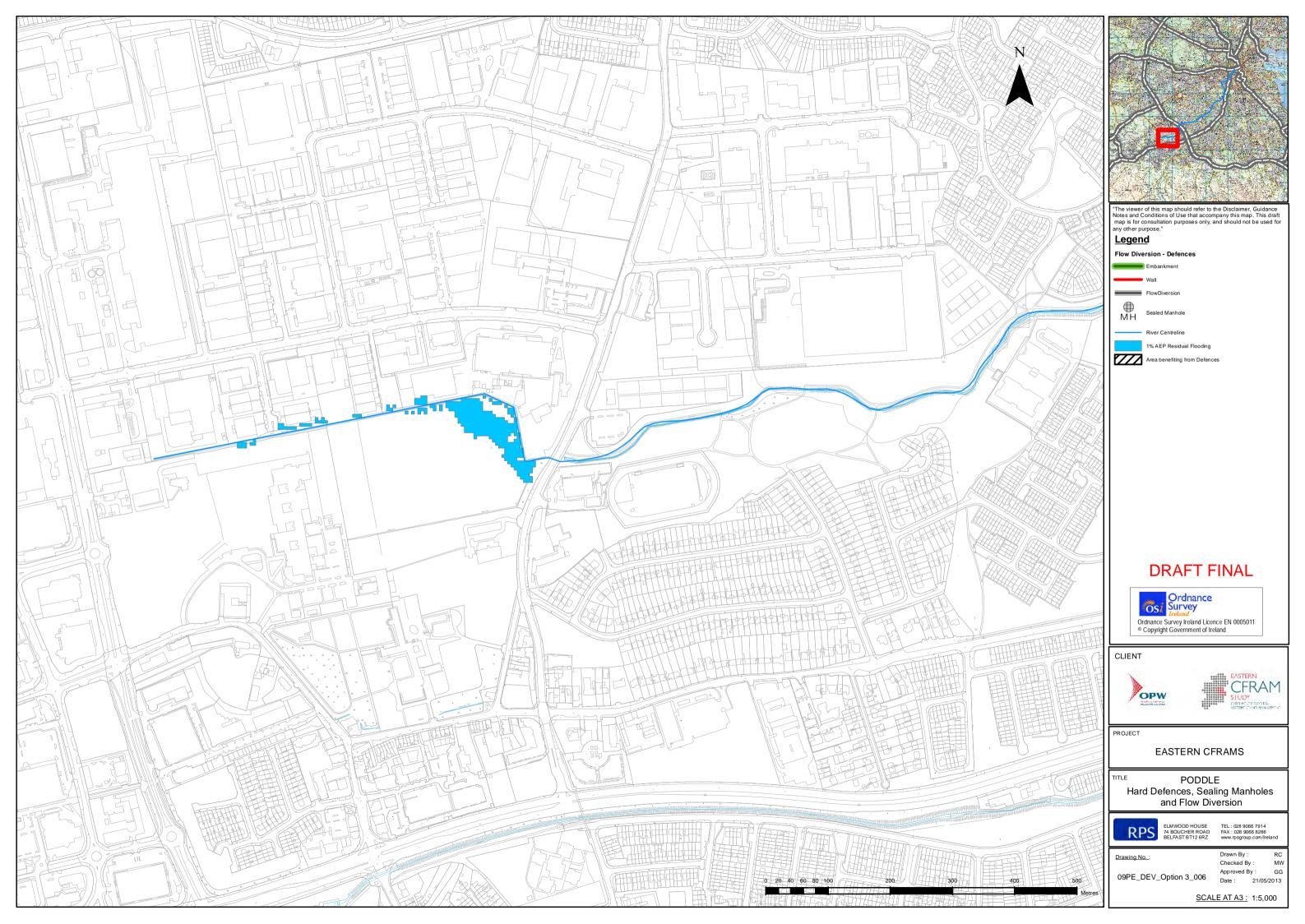
PODDLE
Hard Defences, Sealing Manholes
and Flow Diversion

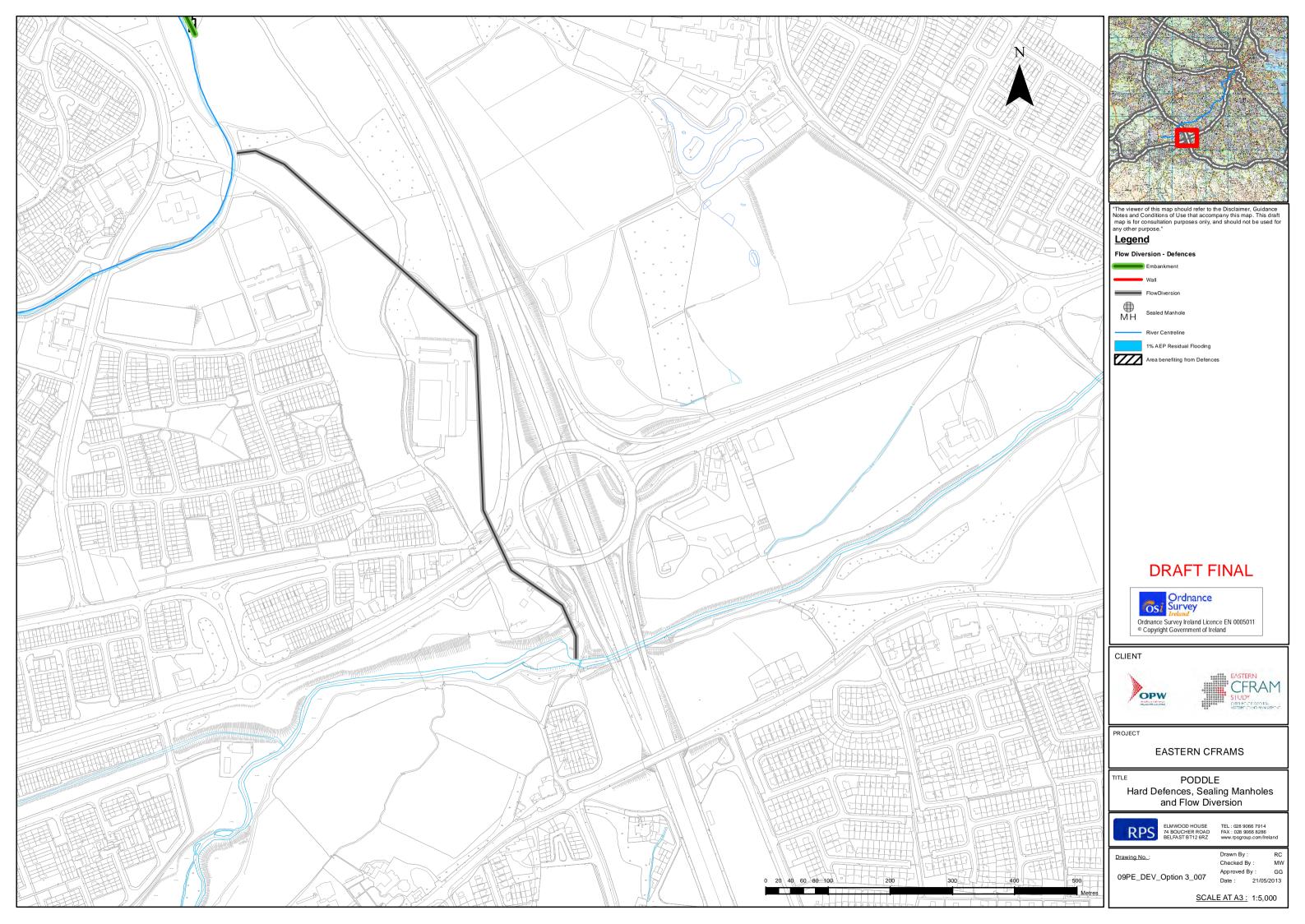
09PE\_DEV\_Option 3\_003 Approve Date :

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# Appendix E Assessment of Poddle Diversion on River Dodder

RPS carried out a hydrological assessment in order to ascertain the hydrological impact on the Dodder catchment of diversion of the flood flows from the Poddle catchment, from a point just upstream of the M50, to the Dodder catchment, again at a point just upstream of the M50.

RPS analysed simultaneous observed flow data from the Waldrons Bridge hydrometric gauging station on the Dodder and simulated flow data from a catchment run-off model located on the Poddle and driven by gauge adjusted rainfall radar data from the Met Éireann radar at Dublin Airport. The simultaneous period for which observed (gauged) and simulated data was available was October 2000 to August 2010. A comparison of the largest three peaks from the Dodder record for this time period with the corresponding hydrograph peaks from the simulated Poddle data is shown in the table below:

| Event 1 – 5 <sup>th</sup> November 2000  | Time of Peak | Difference in Time         | Peak Flow<br>(m³/s) |  |
|--|--------------|----------------------------|---------------------|--|
| Dodder at Waldrons Bridge (09010)        | 23:00        | 50 mins                    | 148.9               |  |
| Poddle at CFRAMS node 09_1874_5_RPS      | 22:10        |                            | 2.1                 |  |
| Event 2 – 2 <sup>nd</sup> December 2003  | Time of Peak | Difference in Time (Hours) | Peak Flow<br>(m³/s) |  |
| Dodder at Waldrons Bridge (09010)        | 08:50        | 1 hour 35 mins             | 103.6               |  |
| Poddle at CFRAMS node 09_1874_5_RPS      | 07:15        |                            | 0.5                 |  |
| Event 3 – 5 <sup>th</sup> September 2008 | Time of Peak | Difference in Time (Hours) | Peak Flow<br>(m³/s) |  |
| Dodder at Waldrons Bridge (09010)        | 14:40        | 2 hours 45 mins            | 108.0               |  |
| Poddle at CFRAMS node 09_1874_5_RPS      | 11:55        |                            | 4.1                 |  |

As can be seen from the table above it seems possible that the flood peaks in both watercourses could potentially coincide as a worst case scenario. Although the catchments are likely to have different reaction times to rainfall events given their sizes, the direction and speed of a passing weather system could be such that this difference in response times is nullified in terms of actual hydrograph peaks.

It must also be considered that the analysis points are different from the proposed diversion points in the two rivers, the gauging station on the Dodder being 5km downstream from the M50 and the catchment run-off node being 2km downstream of the M50. If we were to attempt to transpose these hydrographs backward in time to reflect locations at the M50, it is likely to bring the peak times closer together as the flood peak in the Dodder would be moved back by a greater amount of time than in the Poddle. It must therefore be concluded that if the diversion were to be in place, the flood peak from the transferred Poddle catchment could coincide with the time of the flood peak on the River Dodder.

RPS carried out a hydraulic assessment of the proposal to divert flow from the River Poddle to the River Dodder. These works were based on instruction received from Gavin Poole in the OPW. All model runs were carried out for the 1% AEP fluvial event with a 20%AEP high tide downstream boundary condition.

Two scenarios were investigated. The first scenario modelled included all storage/conveyance improvement options as proposed in the Dodder CFRAM study in conjunction with the recently constructed floodwalls in Ballsbridge and the proposed floodwalls as far as Donnybrook Bridge.

The second scenario modelled included only the flood walls constructed to date in the lower dodder as well as those currently in the Part 8 planning application as far as Donnybrook Bridge.

The Poddle diversion was modelled as a point inflow at Chainage 7200, downstream of the Firhouse Weir and upstream of the M50 overbridge. The Middle Dodder model was run for both scenarios and the outputs of each were used as the boundary inflow hydrographs for the Lower Dodder Model runs.

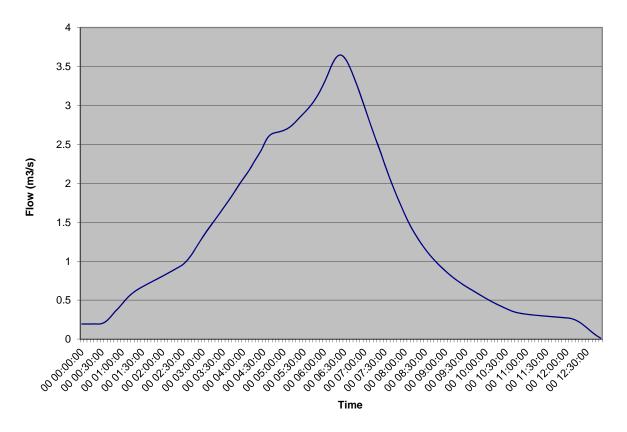
An assessment of the change in water level was made at 3 locations: at the M50, upstream of Donnybrook Bridge and upstream of the DART bridge at Lansdowne Road.

#### Results:

The results of the model runs are presented in the table below. The results of these runs show a relatively small increase in water level (less than 30mm). This is explained by the fact the River Dodder is already in flood at the peak of the Poddle Diversion Discharge Hydrograph (see below), so the 3m<sup>3</sup>/s is distributed over a wide floodplain resulting in a relatively small increase in water level.

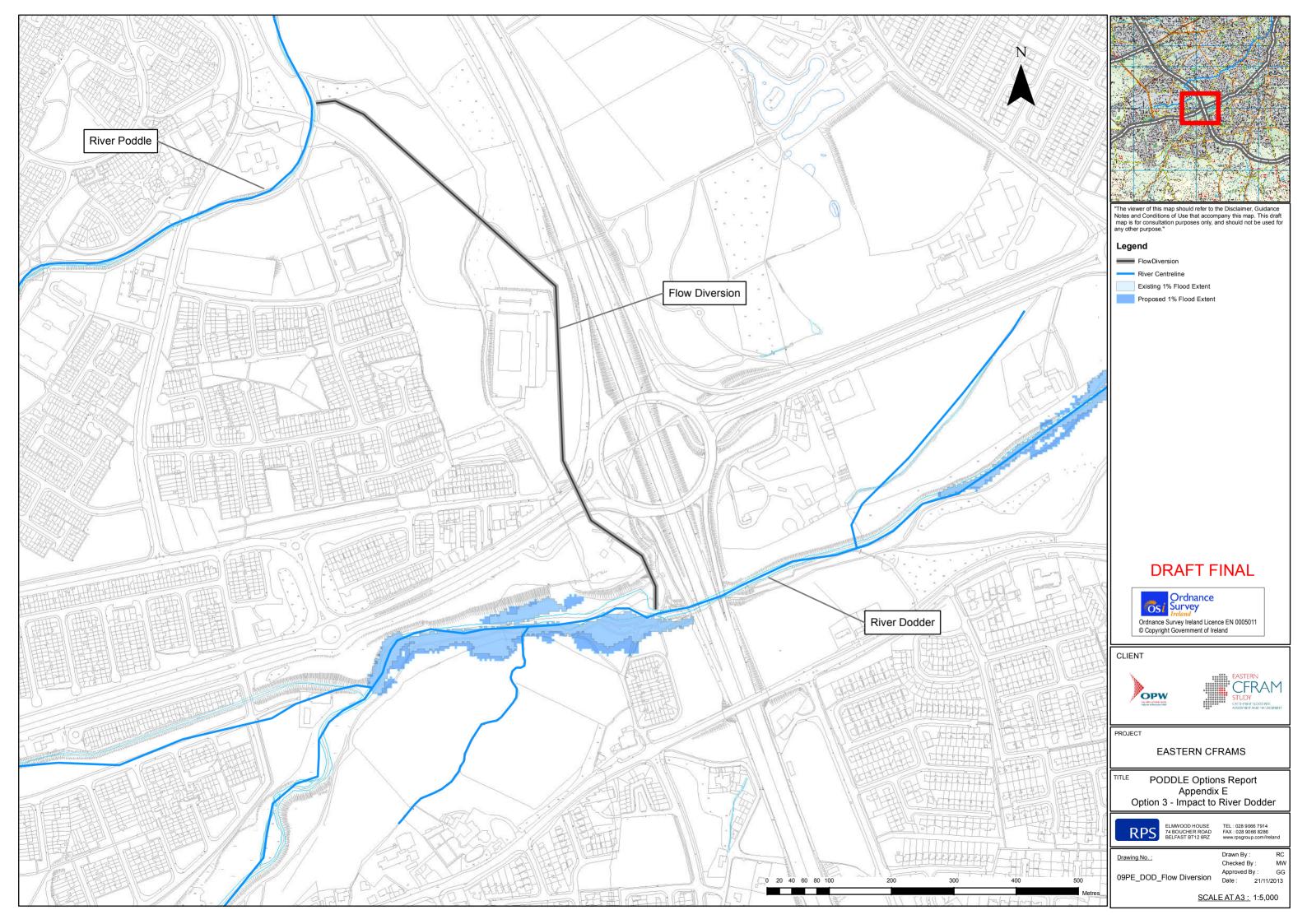
|  | Increase in water level in River Dodder resulting |        |       |  |  |
|--|---|--------|-------|--|--|
| from addition of River Poddle Diversion (m)  |   |        |       |  |  |
| Middle Dodder - Lower Dodder - U/S Lower Dodder - U/S At M50 (Ch 7300)  Lower Dodder - U/S Bridge (Ch 17925) |   |        |       |  |  |
| Donnybrook Walls   | 0.015   | 0.008  | 0.009 |  |  |
| All Options  | 0.03  | 0.0225 | 0.018 |  |  |

Poddle Diversion Discharge Hydrograph (m3/s)



The proceeding pages detail the following:

- Layout map of proposed diversion route
- Water surface profile of the River Dodder showing the 1%AEP event for the existing and proposed diversion scenarios
- Flow hydrographs of the 1% AEP event of the River Dodder
- Map showing the existing and proposed diversion scenario flood extents with properties affected.

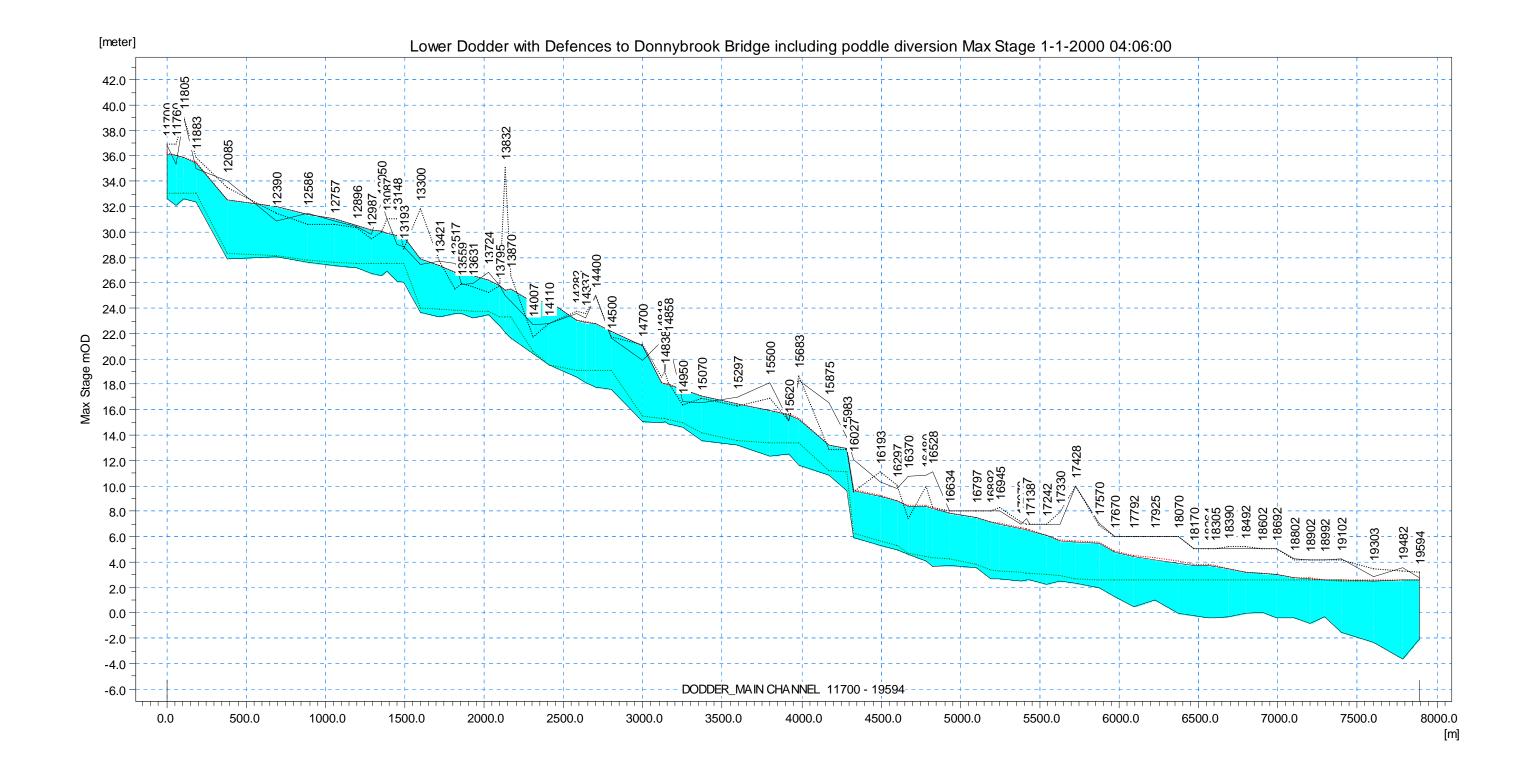


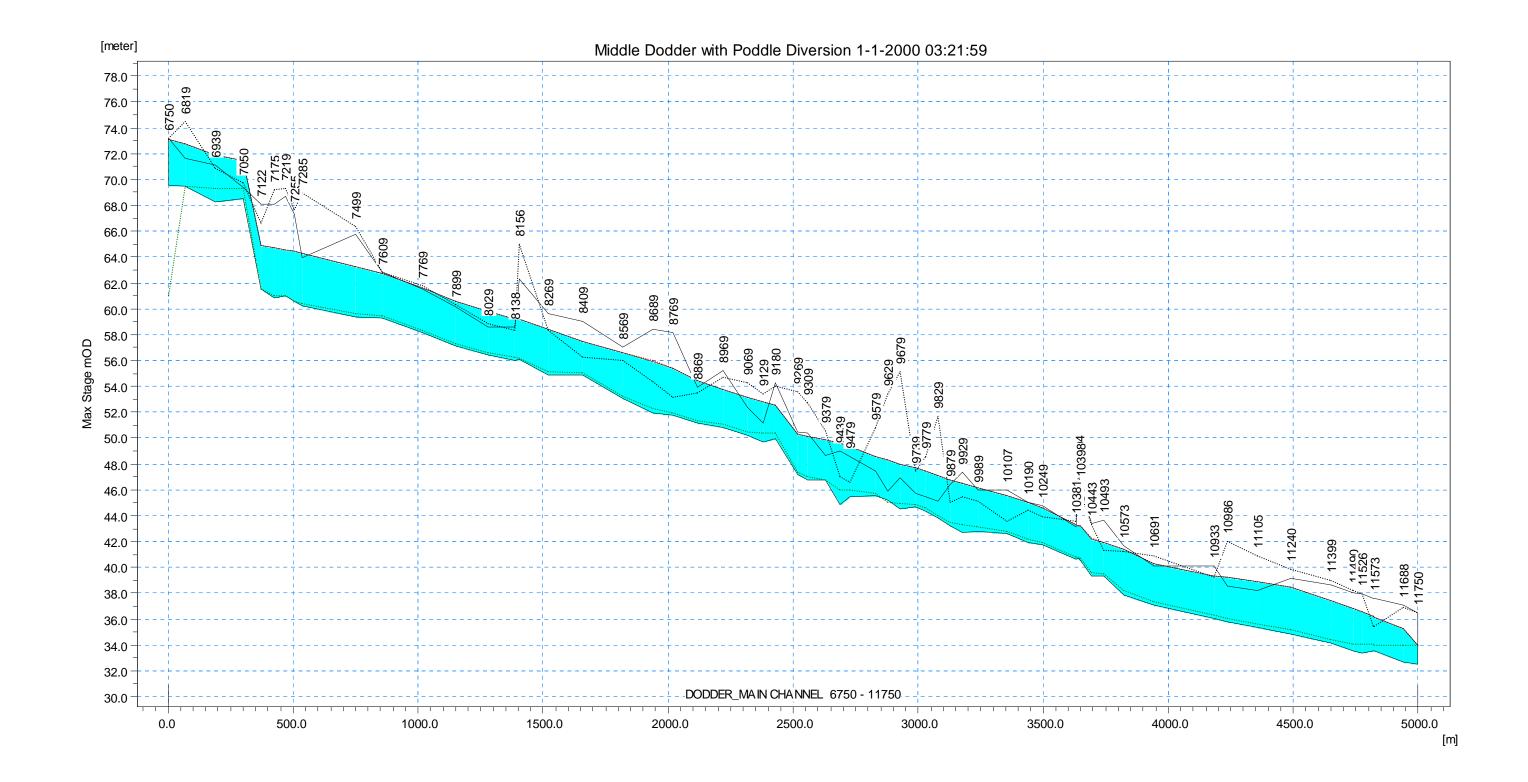
| Middle Dodder Model |                 |                   |                 |                         |
|---------------------|-----------------|-------------------|-----------------|-------------------------|
| Chainage            | Bed<br>Level    | MaximumWaterLevel | MaximumWLPoddle | Increase in water level |
| 6750                | 69.521          | 72.981            | 73.135          | 0.154                   |
| 6818.9              | 69.46           | 72.559            | 73.133          | 0.134                   |
| 6938.9              | 68.25           | 71.507            | 71.921          | 0.228                   |
| 7050                | 68.542          | 71.507            | 71.921          | 0.414                   |
| 7121.7              |                 |                   | 64.862          |                         |
|                     | 61.52           | 64.997            |                 | -0.135                  |
| 7174.8<br>7218.6    | 60.86<br>60.969 | 64.768<br>64.54   | 64.694          | -0.074                  |
| 7216.6              |                 |                   | 64.554          | 0.014                   |
| 7284.5              | 60.61<br>60.2   | 64.418            | 64.433          | 0.015<br>0.015          |
|                     |                 | 64.28             | 64.295          |                         |
| 7498.9              | 59.41<br>59.3   | 63.257            | 63.276          | 0.019                   |
| 7608.9              |                 | 62.721            | 62.742          | 0.021                   |
| 7768.9              | 58.2            | 61.585            | 61.61           | 0.025                   |
| 7898.9              | 57.15           | 60.551            | 60.59           | 0.039                   |
| 8028.9              | 56.39           | 59.76             | 59.774          | 0.014                   |
| 8137.9              | 55.96           | 59.21             | 59.229          | 0.019                   |
| 8155.7              | 56.05           | 59.146            | 59.177          | 0.031                   |
| 8268.9              | 54.84           | 58.339            | 58.398          | 0.059                   |
| 8408.9              | 54.9            | 57.338            | 57.467          | 0.129                   |
| 8568.9              | 53.07           | 56.595            | 56.646          | 0.051                   |
| 8688.9              | 51.96           | 55.882            | 55.961          | 0.079                   |
| 8768.9              | 51.81           | 55.377            | 55.411          | 0.034                   |
| 8868.9              | 51.17           | 54.35             | 54.411          | 0.061                   |
| 8968.9              | 50.86           | 53.742            | 53.752          | 0.01                    |
| 9068.9              | 50.17           | 53.173            | 53.191          | 0.018                   |
| 9128.9              | 49.68           | 52.807            | 52.818          | 0.011                   |
| 9180                | 49.98           | 52.544            | 52.553          | 0.009                   |
| 9268.9              | 47.16           | 50.242            | 50.292          | 0.05                    |
| 9308.9              | 46.75           | 50.095            | 50.155          | 0.06                    |
| 9378.9              | 46.76           | 49.775            | 49.849          | 0.074                   |
| 9438.9              | 44.89           | 49.502            | 49.574          | 0.072                   |
| 9478.9              | 45.5            | 49.264            | 49.34           | 0.076                   |
| 9578.9              | 45.55           | 48.496            | 48.533          | 0.037                   |
| 9628.9              | 45.2            | 48.313            | 48.354          | 0.041                   |
| 9678.9              | 44.52           | 47.935            | 47.986          | 0.051                   |
| 9738.9              | 44.68           | 47.646            | 47.692          | 0.046                   |
| 9778.9              | 44.37           | 47.421            | 47.455          | 0.034                   |
| 9828.9              | 43.79           | 47.051            | 47.099          | 0.048                   |
| 9878.9              | 43.24           | 46.712            | 46.726          | 0.014                   |
| 9928.9              | 42.7            | 46.495            | 46.508          | 0.013                   |
| 9988.9              | 42.78           | 46.153            | 46.171          | 0.018                   |
| 10106.6             | 42.65           | 45.496            | 45.515          | 0.019                   |
| 10189.9             | 41.9            | 45.007            | 45.03           | 0.023                   |
| 10248.7             | 41.73           | 44.599            | 44.618          | 0.019                   |
| 10381.2             | 40.6            | 43.314            | 43.328          | 0.014                   |
| 10392               | 40.721          | 43.233            | 43.248          | 0.015                   |
| 10394.2             | 40.6            | 43.21             | 43.224          | 0.014                   |
| 10398.3             | 40.58           | 43.167            | 43.182          | 0.015                   |
| 10443.2             | 39.32           | 42.201            | 42.223          | 0.022                   |
| 10492.5             | 39.31           | 41.912            | 41.936          | 0.024                   |

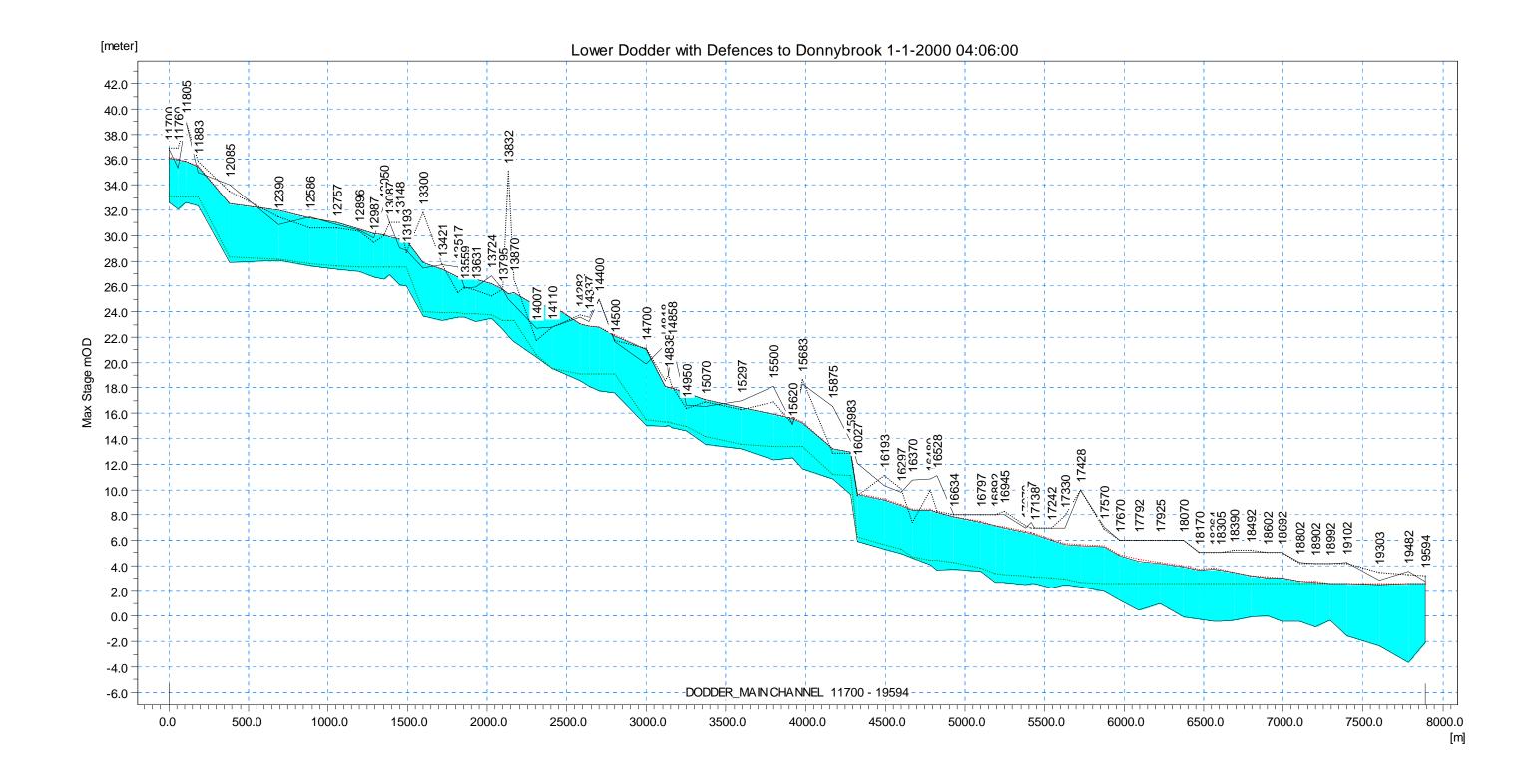
| Middle Dodder Model |        |                   |                 |                   |
|---------------------|--------|-------------------|-----------------|-------------------|
|                     | Bed    |                   |                 | Increase in water |
| Chainage            | Level  | MaximumWaterLevel | MaximumWLPoddle | level             |
| 10573.4             | 37.83  | 41.336            | 41.369          | 0.033             |
| 10690.9             | 37.12  | 40.295            | 40.31           | 0.015             |
| 10932.5             | 36.078 | 39.352            | 39.371          | 0.019             |
| 10986.4             | 35.75  | 39.235            | 39.254          | 0.019             |
| 11104.9             | 35.35  | 38.849            | 38.864          | 0.015             |
| 11240.2             | 34.84  | 38.443            | 38.46           | 0.017             |
| 11399               | 34.19  | 37.441            | 37.456          | 0.015             |
| 11490.1             | 33.572 | 36.804            | 36.818          | 0.014             |
| 11525.6             | 33.34  | 36.523            | 36.538          | 0.015             |
| 11568               | 33.58  | 36.203            | 36.221          | 0.018             |
| 11573               | 33.58  | 36.116            | 36.134          | 0.018             |
| 11688               | 32.69  | 35.248            | 35.256          | 0.008             |
| 11750               | 32.52  | 34                | 34              | 0                 |

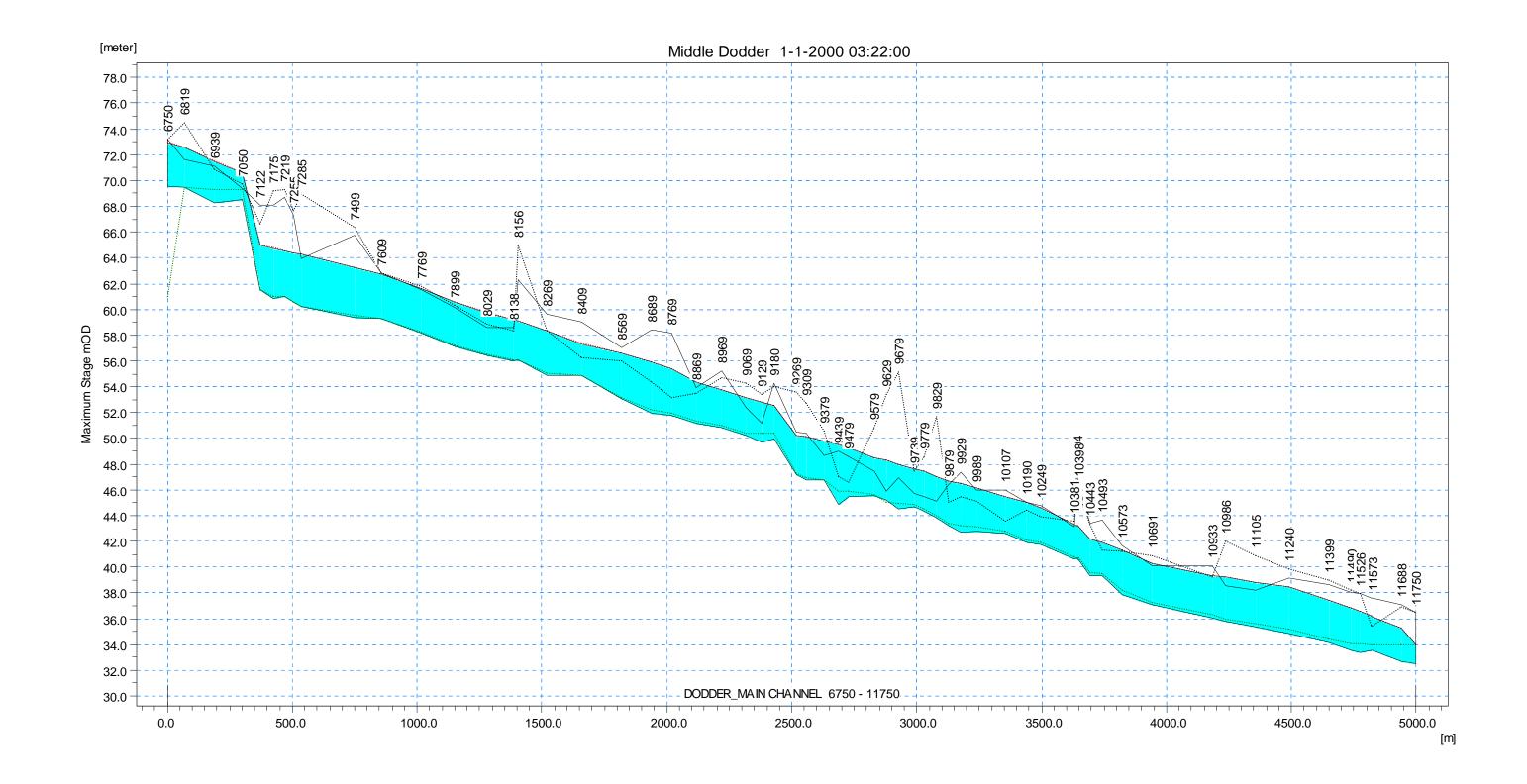
| Lower Dodder Model |        |                   |                    |                   |
|--------------------|--------|-------------------|--------------------|-------------------|
| Chainean           | Bed    | Maximum Matarlaya | Maximum W/I Daddla | Increase in water |
| Chainage           | Level  | MaximumWaterLevel | MaximumWLPoddle    | level             |
| 11700              | 32.592 | 36.183            | 36.198             | 0.015             |
| 11760              | 32.1   | 36.014            | 36.031             | 0.017             |
| 11805              | 32.65  | 35.859            | 35.877             | 0.018             |
| 11882.6            | 32.37  | 35.48             | 35.495             | 0.015             |
| 12084.8            | 27.9   | 32.535            | 32.547             | 0.012             |
| 12389.6            | 28.03  | 31.968            | 31.978             | 0.01              |
| 12585.7            | 27.6   | 31.403            | 31.406             | 0.003             |
| 12756.8            | 27.32  | 31.066            | 31.071             | 0.005             |
| 12896              | 27.15  | 30.47             | 30.473             | 0.003             |
| 12986.9            | 26.73  | 30.187            | 30.189             | 0.002             |
| 13050              | 26.6   | 30.074            | 30.079             | 0.005             |
| 13087              | 26.912 | 29.859            | 29.863             | 0.004             |
| 13148              | 26.08  | 29.708            | 29.714             | 0.006             |
| 13192.5            | 26.05  | 29.62             | 29.626             | 0.006             |
| 13299.7            | 23.63  | 27.839            | 27.845             | 0.006             |
| 13421              | 23.27  | 27.311            | 27.318             | 0.007             |
| 13517              | 23.55  | 26.773            | 26.778             | 0.005             |
| 13559              | 23.57  | 26.712            | 26.722             | 0.01              |
| 13631.4            | 23.19  | 26.56             | 26.57              | 0.01              |
| 13724.4            | 23.49  | 26.195            | 26.205             | 0.01              |
| 13795              | 22.564 | 25.754            | 25.772             | 0.018             |
| 13832              | 22.089 | 25.431            | 25.442             | 0.011             |
| 13869.6            | 21.66  | 25.476            | 25.489             | 0.013             |
| 14006.9            | 20.39  | 24.452            | 24.472             | 0.02              |
| 14110.1            | 19.49  | 24.518            | 24.536             | 0.018             |
| 14282.3            | 18.55  | 23.051            | 23.064             | 0.013             |
| 14337.4            | 18.103 | 22.899            | 22.913             | 0.014             |
| 14400              | 17.748 | 22.776            | 22.79              | 0.014             |
| 14500              | 17.634 | 22.138            | 22.148             | 0.01              |
| 14700              | 15.013 | 20.99             | 20.991             | 0.001             |
| 14818              | 14.96  | 18.148            | 18.151             | 0.003             |
| 14838              | 15.014 | 18.015            | 18.018             | 0.003             |
| 14858              | 14.91  | 17.995            | 17.999             | 0.004             |
| 14950              | 14.6   | 17.577            | 17.581             | 0.004             |
| 15070              | 13.603 | 17.104            | 17.108             | 0.004             |
| 15297              | 13.19  | 16.438            | 16.44              | 0.002             |
| 15500              | 12.32  | 15.963            | 15.967             | 0.004             |
| 15620              | 12.478 | 15.64             | 15.644             | 0.004             |
| 15683              | 11.62  | 15.274            | 15.277             | 0.003             |
| 15875              | 10.85  | 13.248            | 13.251             | 0.003             |
| 15982.5            | 9.59   | 12.963            | 12.966             | 0.003             |
| 16026.5            | 5.96   | 9.699             | 9.707              | 0.008             |
| 16192.9            | 5.27   | 9.25              | 9.258              | 0.008             |
| 16297.4            | 4.98   | 8.836             | 8.843              | 0.007             |
| 16369.8            | 4.59   | 8.459             | 8.501              | 0.042             |
| 16480.3            | 4.077  | 8.44              | 8.446              | 0.006             |
| 16528.4            | 3.651  | 8.246             | 8.252              | 0.006             |
| 16634              | 3.738  | 7.871             | 7.876              | 0.005             |
| 16797              | 3.585  | 7.513             | 7.518              | 0.005             |

| Lower Dodder Model |        |                   |                 |                   |
|--------------------|--------|-------------------|-----------------|-------------------|
|                    | Bed    |                   |                 | Increase in water |
| Chainage           | Level  | MaximumWaterLevel | MaximumWLPoddle | level             |
| 16892.1            | 2.701  | 7.178             | 7.182           | 0.004             |
| 16945              | 2.672  | 7.053             | 7.056           | 0.003             |
| 17079.2            | 2.469  | 6.681             | 6.682           | 0.001             |
| 17116.5            | 2.581  | 6.601             | 6.602           | 0.001             |
| 17138.3            | 2.626  | 6.521             | 6.522           | 0.001             |
| 17241.7            | 2.274  | 6.132             | 6.134           | 0.002             |
| 17330              | 2.53   | 5.755             | 5.781           | 0.026             |
| 17427.9            | 2.308  | 5.683             | 5.689           | 0.006             |
| 17570              | 1.981  | 5.567             | 5.573           | 0.006             |
| 17669.5            | 1.285  | 4.854             | 4.861           | 0.007             |
| 17792              | 0.431  | 4.475             | 4.482           | 0.007             |
| 17925.3            | 0.978  | 4.287             | 4.296           | 0.009             |
| 18070              | -0.096 | 4.03              | 4.039           | 0.009             |
| 18170              | -0.225 | 3.762             | 3.769           | 0.007             |
| 18264              | -0.36  | 3.783             | 3.79            | 0.007             |
| 18305              | -0.419 | 3.747             | 3.754           | 0.007             |
| 18390              | -0.302 | 3.477             | 3.481           | 0.004             |
| 18491.8            | -0.01  | 3.23              | 3.234           | 0.004             |
| 18601.8            | 0.008  | 3.108             | 3.112           | 0.004             |
| 18691.8            | -0.363 | 3.032             | 3.036           | 0.004             |
| 18801.8            | -0.433 | 2.799             | 2.8             | 0.001             |
| 18901.8            | -0.804 | 2.723             | 2.724           | 0.001             |
| 18991.8            | -0.327 | 2.588             | 2.584           | -0.004            |
| 19101.8            | -1.567 | 2.577             | 2.576           | -0.001            |
| 19303.3            | -2.295 | 2.57              | 2.578           | 0.008             |
| 19482              | -3.638 | 2.568             | 2.568           | 0                 |
| 19589.2            | -2.034 | 2.56              | 2.56            | 0                 |
| 19594              | -2.034 | 2.56              | 2.56            | 0                 |

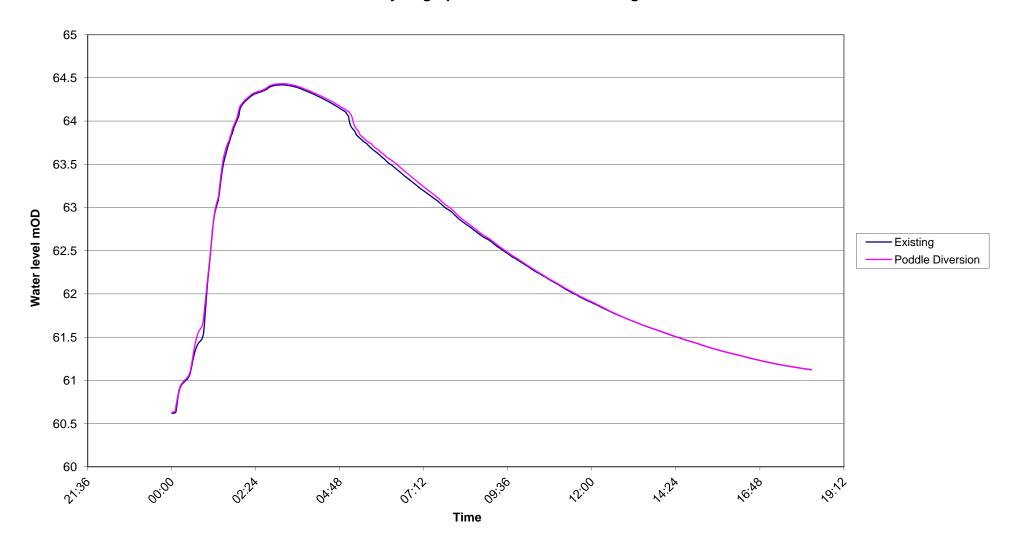




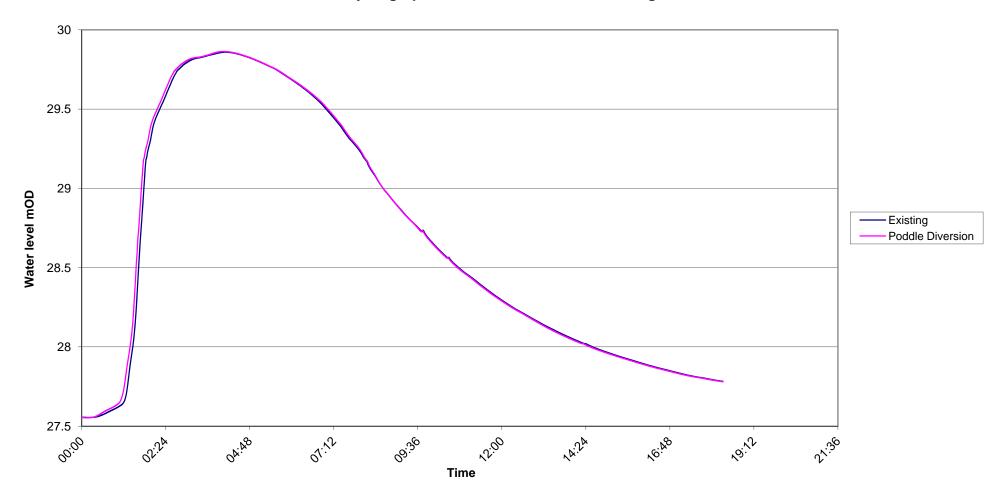




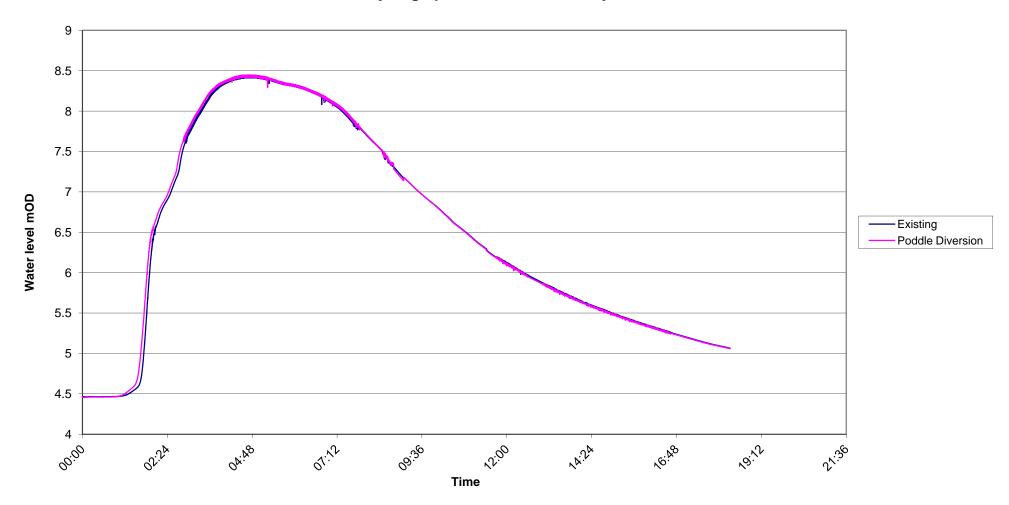
## 1%AEP Hydrographs at CH7254m M50 Bridge



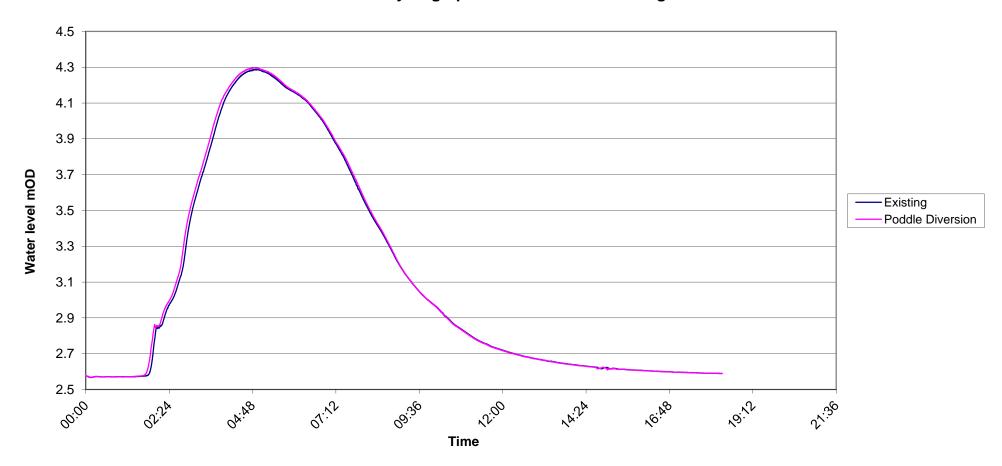
# 1%AEP Hydrographs at CH13087m Waldron's Bridge

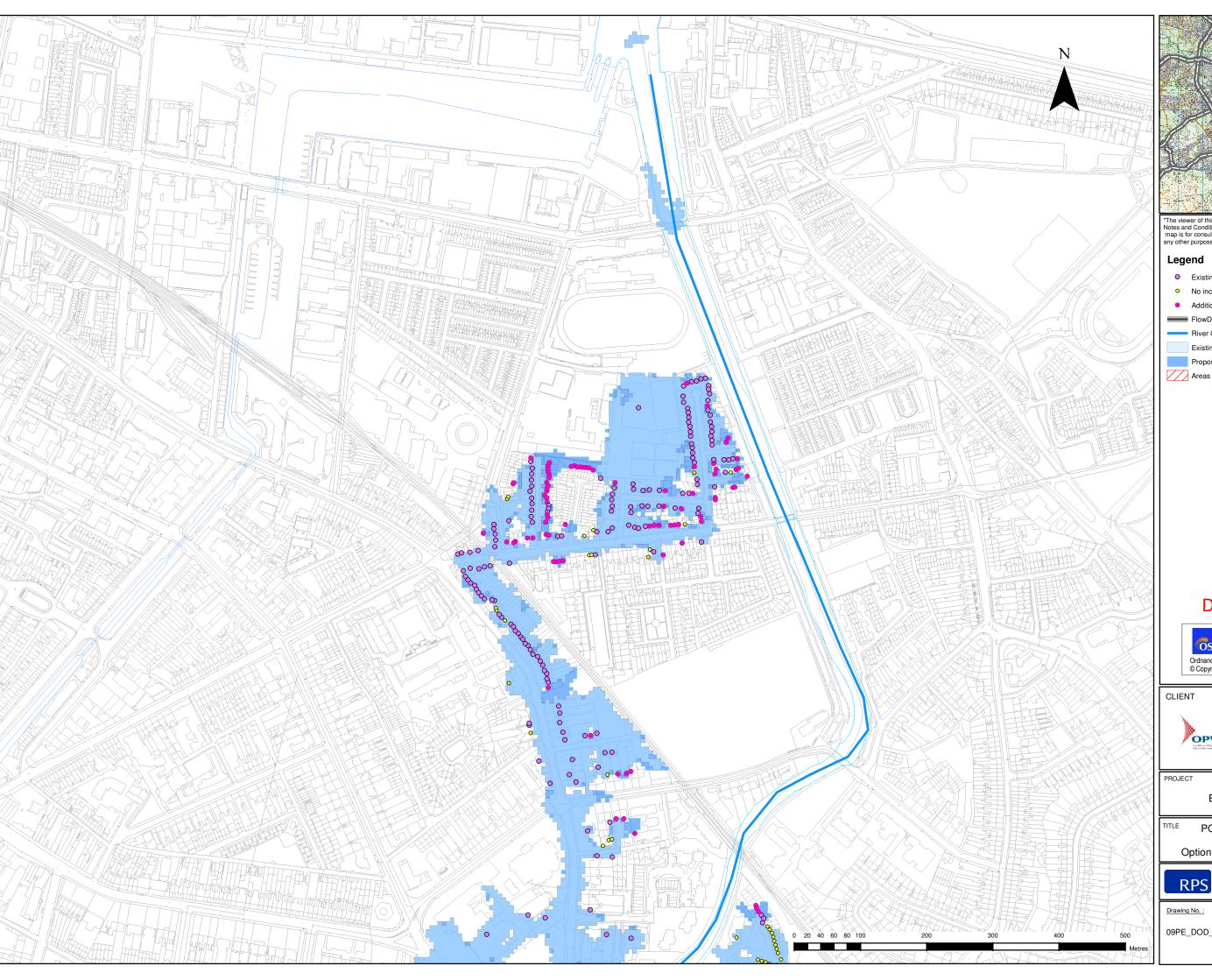


# 1%AEP Hydrographs at CH16480m Donnybrook



# **1%AEP Hydrographs at CH17925m Dartbridge**







- Existing properties with increased risk
- No increase in risk
- Additional properties at risk
- FlowDiversion
- River Centreline
- Existing 1% Flood Extent
- Proposed 1% Flood Extent
- Areas not proposed for protection

## **DRAFT FINAL**



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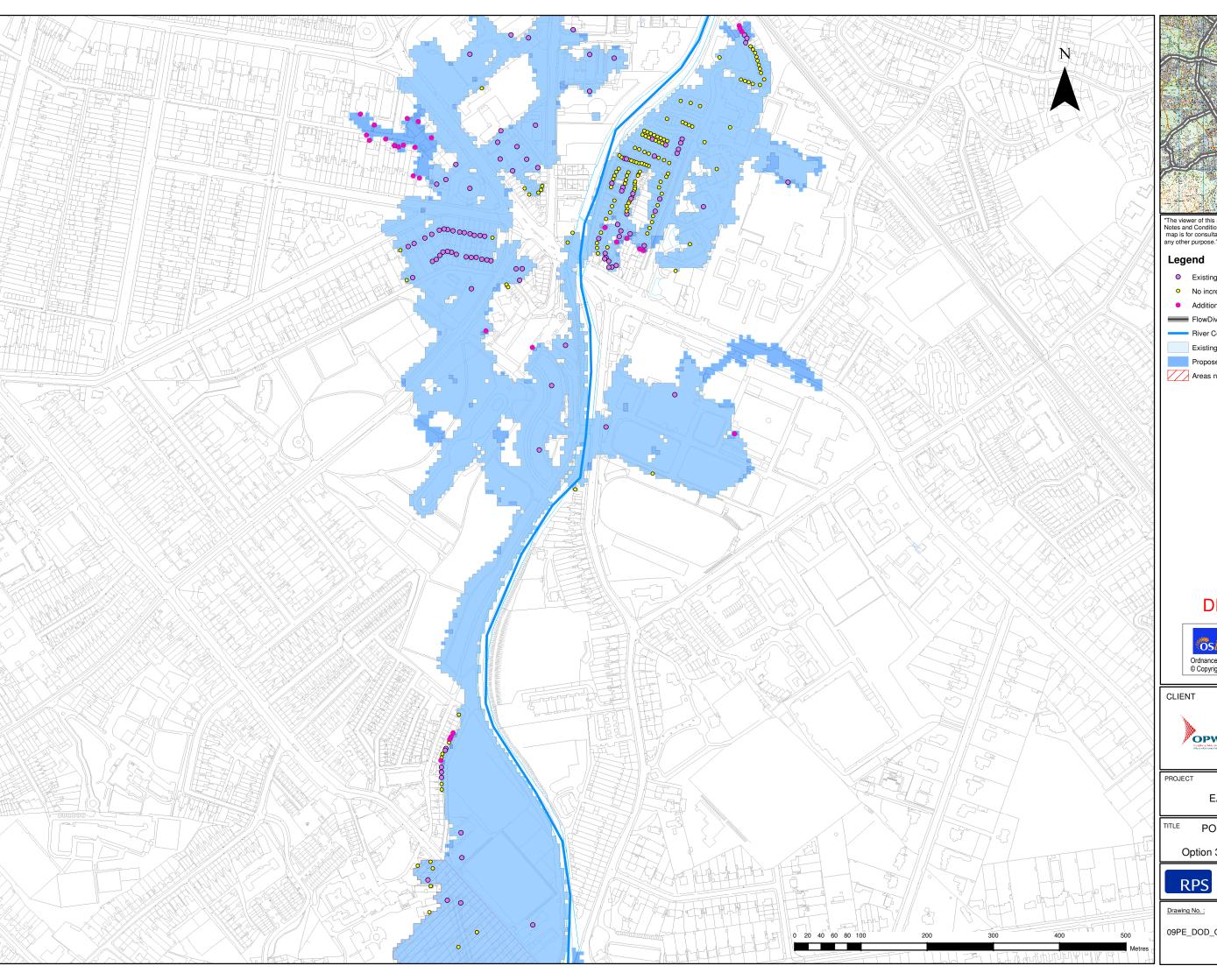
### **EASTERN CFRAMS**

PODDLE Options Report
Appendix E
Option 3 - Impact to River Dodder



Approved By: GG
Date: 21/11/2013 09PE\_DOD\_Option 3\_001

SCALE AT A3 : 1:5,000





- Existing properties with increased risk
- No increase in risk
- Additional properties at risk
- River Centreline
- Existing 1% Flood Extent
- Proposed 1% Flood Extent
- Areas not proposed for protection

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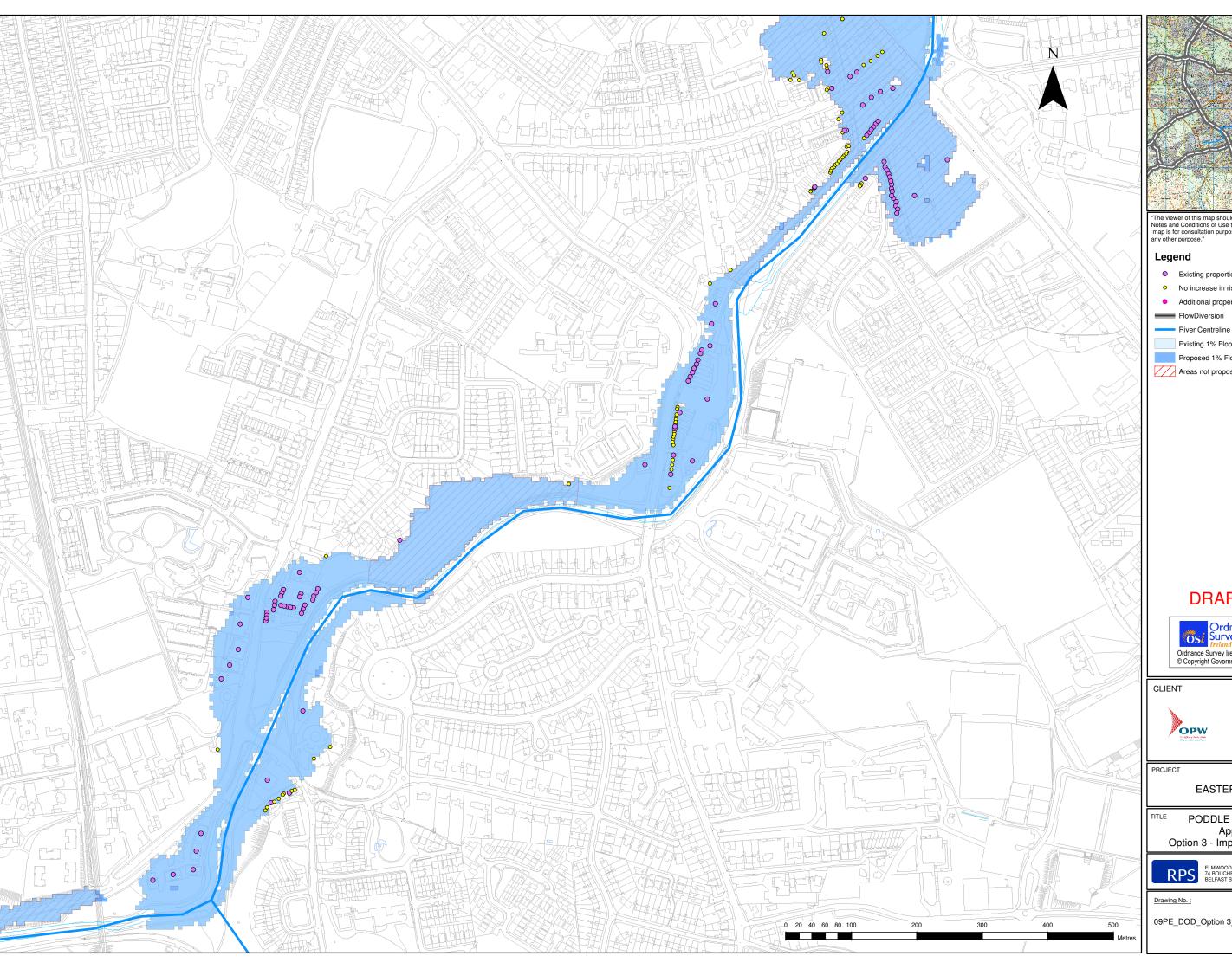


### EASTERN CFRAMS

PODDLE Options Report
Appendix E
Option 3 - Impact to River Dodder



SCALE AT A3: 1:5,000





- Existing properties with increased risk
- No increase in risk
- Additional properties at risk

- Existing 1% Flood Extent
- Proposed 1% Flood Extent
- Areas not proposed for protection

## **DRAFT FINAL**







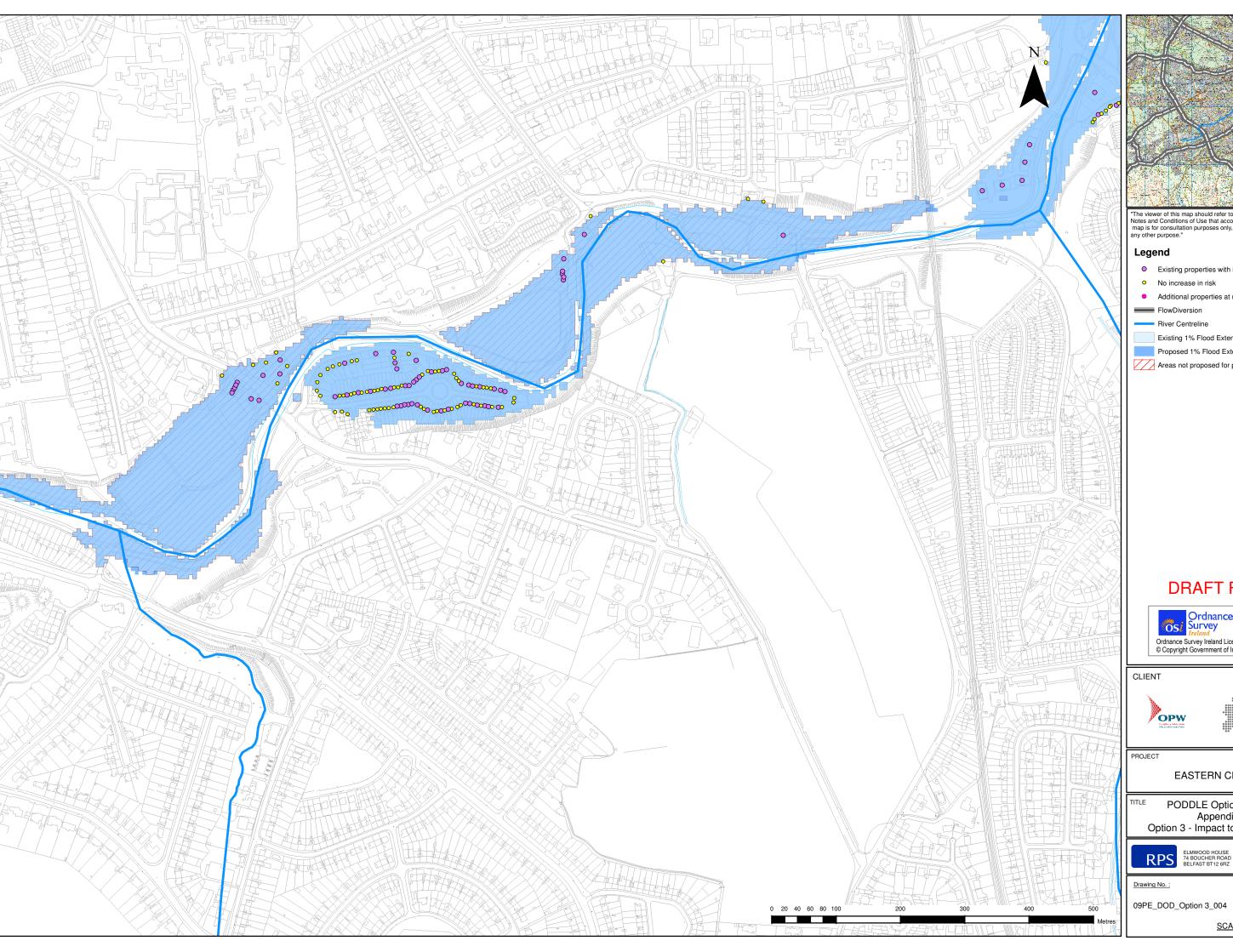
### EASTERN CFRAMS

PODDLE Options Report
Appendix E
Option 3 - Impact to River Dodder



Approved By: GG
Date: 21/11/2013 09PE\_DOD\_Option 3\_003

SCALE AT A3 : 1:5,000





- Existing properties with increased risk
- Additional properties at risk
- River Centreline
- Existing 1% Flood Extent
- Proposed 1% Flood Extent
- Areas not proposed for protection

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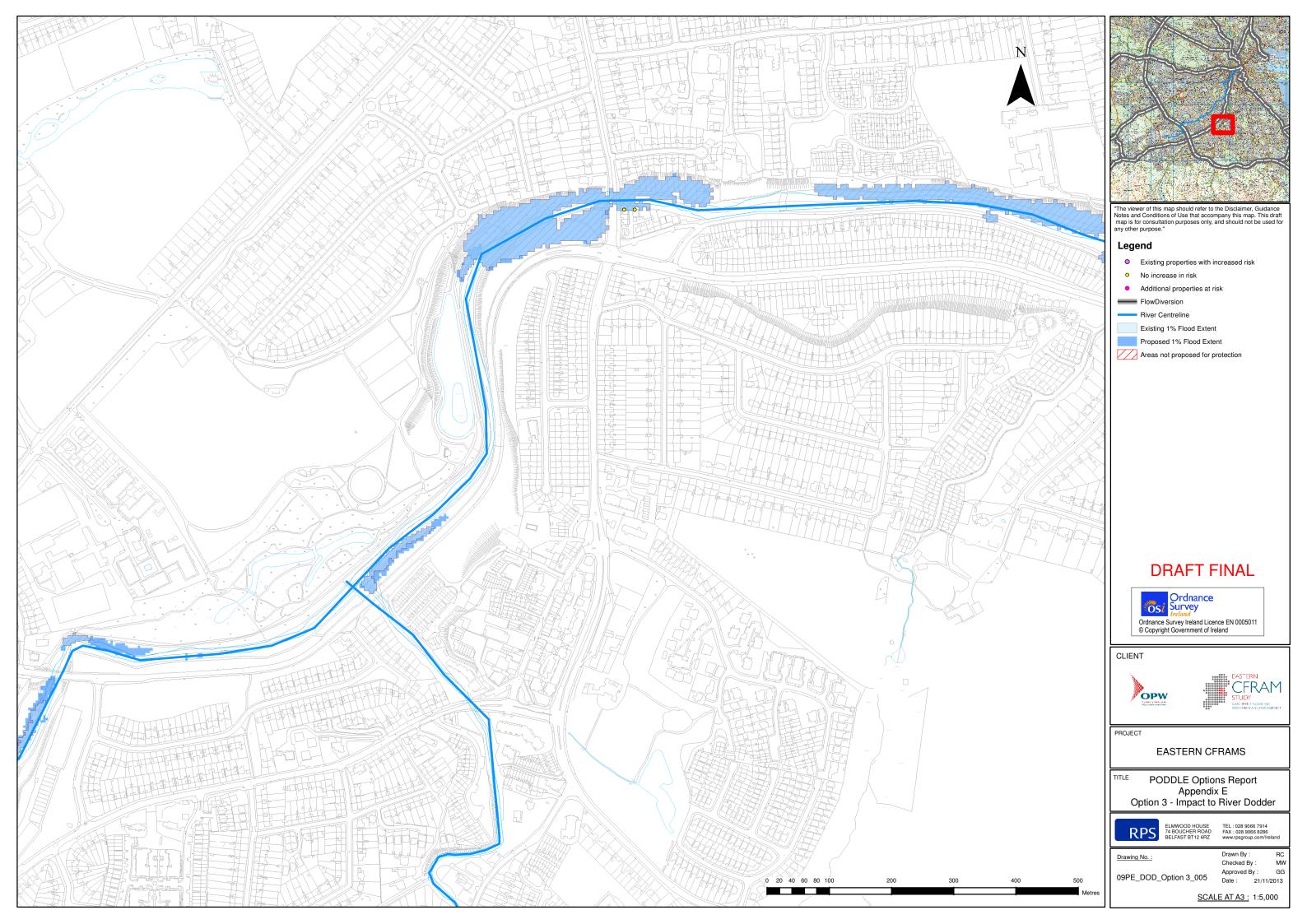


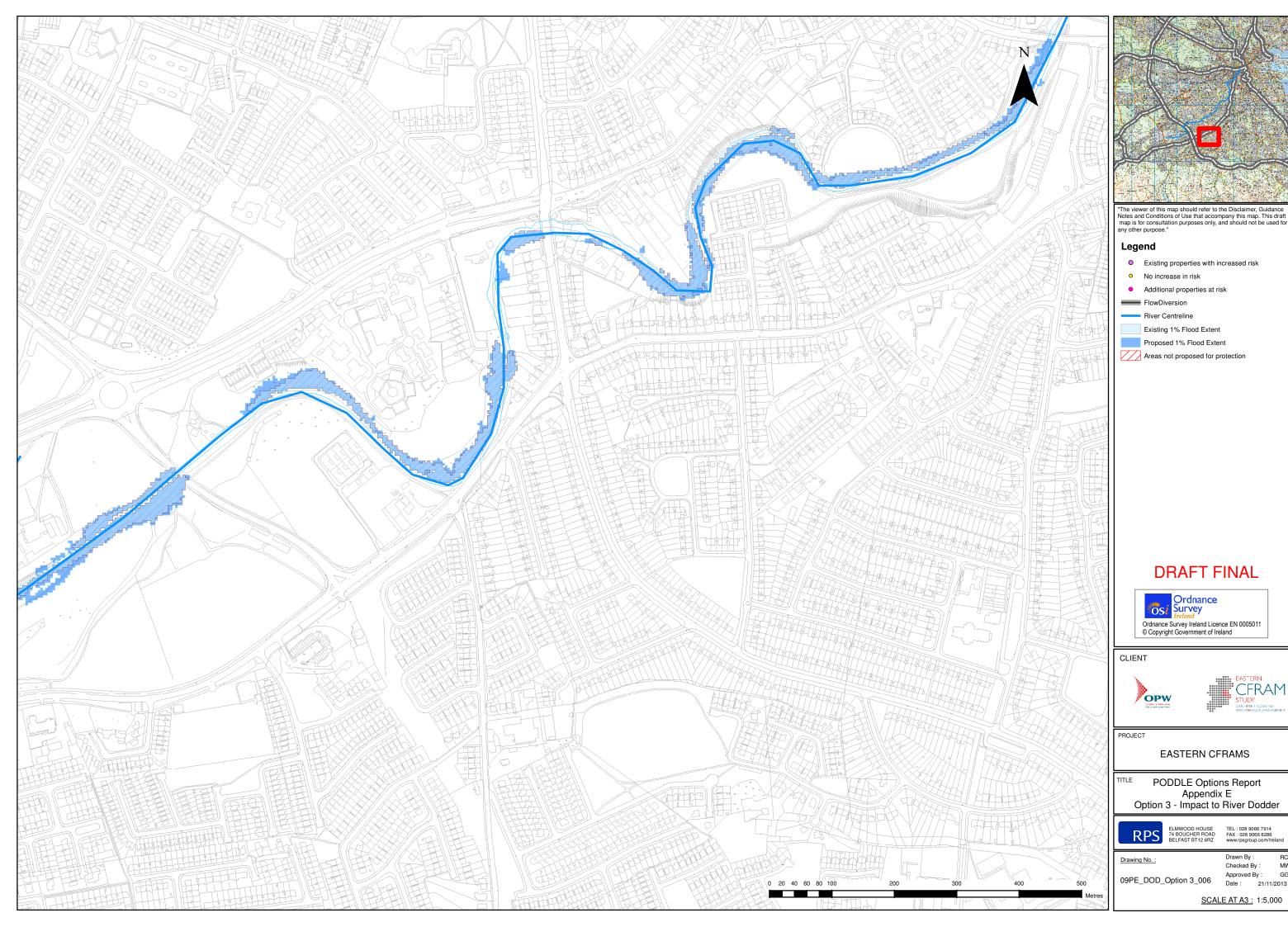
### **EASTERN CFRAMS**

PODDLE Options Report
Appendix E
Option 3 - Impact to River Dodder

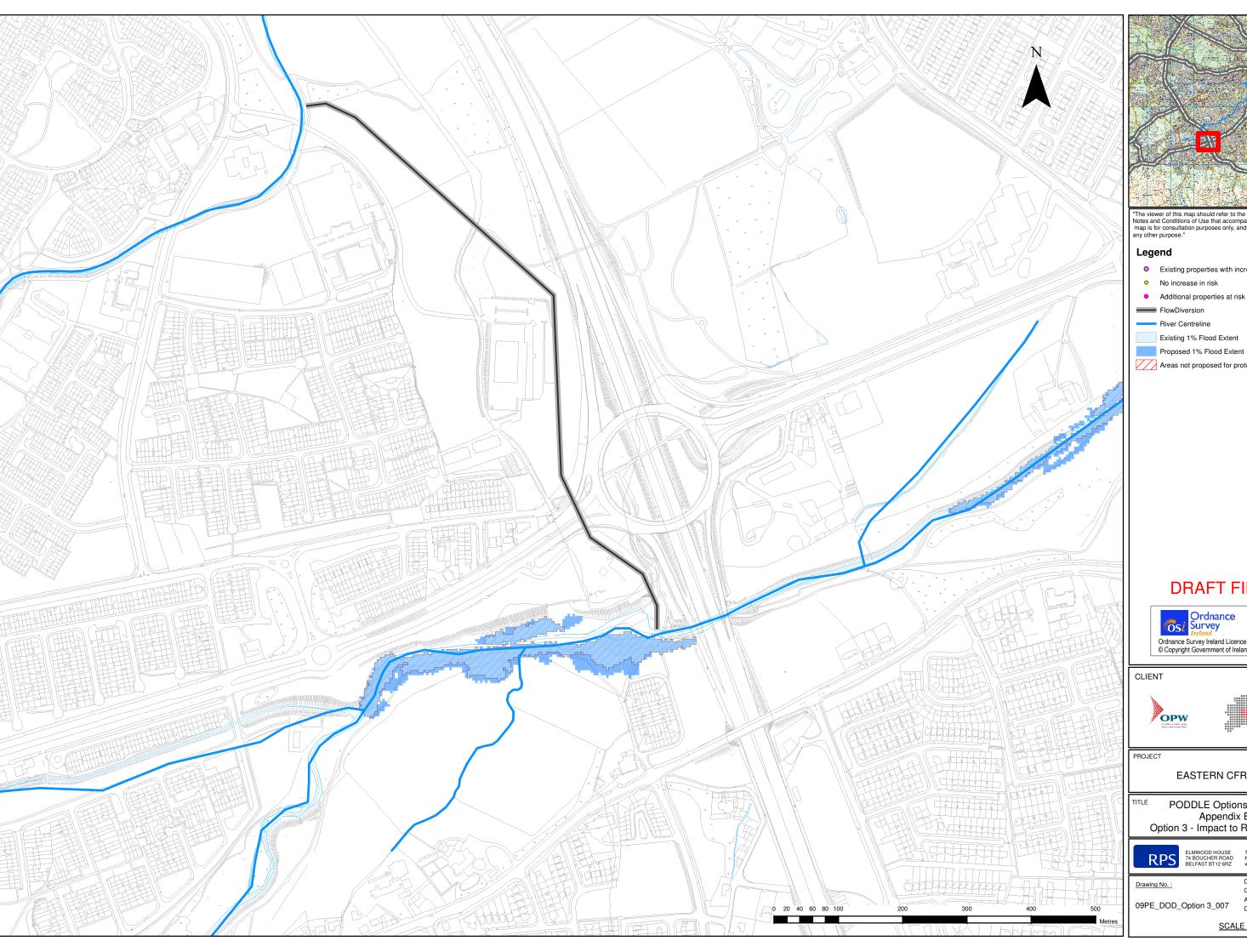
Approved By :

SCALE AT A3: 1:5,000





Drawn By :





- Existing properties with increased risk
- Additional properties at risk
- Existing 1% Flood Extent
- Areas not proposed for protection

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### EASTERN CFRAMS

PODDLE Options Report
Appendix E
Option 3 - Impact to River Dodder

Drawn By: Approved By: GG
Date: 21/11/2013

SCALE AT A3: 1:5,000