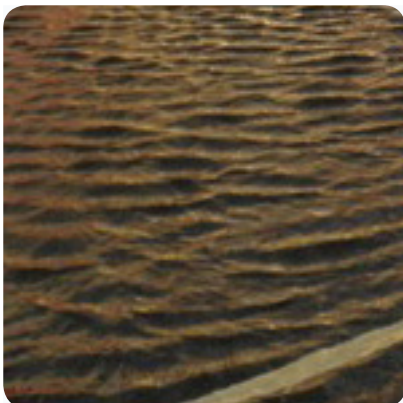


Raphoe Flood Risk Assessment and Management Study

Options Report

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Raphoe Flood Risk Assessment and Management Study

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TABLE OF CONTENTS

APPENDICES	V
ABBREVIATIONS.....	VI
1 INTRODUCTION.....	7
1.1 PURPOSE OF THE OPTIONS REPORT	9
1.2 INTRODUCTION TO THE OPTIONEERING PROCESS.....	9
2 DATA COLLECTION	11
2.1 BACKGROUND MAPPING.....	11
2.2 RECEPTORS	11
2.3 FLOOD HAZARD	12
2.4 SURVEY DATA	12
2.5 ECONOMIC ASSESSMENT	12
3 FLOOD RISK ASSESSMENT	13
3.1 FLOOD RISK MAPS.....	13
3.2 FLOOD RISK WITHIN RAPHOE.....	15
4 DAMAGE ASSESSMENT.....	16
4.1 DAMAGE ASSESSMENT GUIDELINES.....	16
4.2 RECORDING DAMAGE ASSESSMENT DATA	16
4.3 CATEGORISATION OF PROPERTIES	17
4.4 PROPERTY THRESHOLD LEVEL	19
4.5 FLOOD DEPTH OF PROPERTIES	21
4.6 FLOOD DAMAGE TO PROPERTIES.....	22
4.7 INTANGIBLE DAMAGES AND EMERGENCY COSTS	23
4.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE.....	24
4.9 CAPPING DAMAGES	25
4.10 DAMAGE ASSESSMENT REVIEW.....	25
4.11 SUMMARY OF DAMAGES IN RAPHOE.....	25
4.12 LIMITATIONS OF THE FLOOD DAMAGE ASSESSMENT	26
5 FLOOD RISK MANAGEMENT MEASURES.....	27
5.1 STANDARD OF PROTECTION	27
5.1.1 Residual Risk	27
5.2 LIST OF FRM MEASURES	28
5.3 BASELINE CONDITION	29
6 ASSESSMENT OF FRM MEASURES	30
6.1 SCREENING FLOOD RISK MANAGEMENT MEASURES.....	31
6.1.1 Applicability Review of FRM Measures.....	31
6.1.2 Flooding Mechanisms	32
6.1.3 Technical Review of FRM Measures	32
6.1.4 Environmental and Social Review	34
6.2 DEVELOPING POTENTIAL FRM OPTIONS	35
6.2.1 Further Technical Analysis of Primary Measures to Produce Potential FRM Options.....	35
6.3 ASSESSMENT OF POTENTIAL FRM OPTIONS	35
6.3.1 The Benefit Cost Ratio (BCR)	36
6.3.2 The Multi-Criteria Analysis (MCA) Methodology	37
6.3.3 Overall net benefit methodology	38
6.3.4 Net Benefit Scores	38
6.4 SUMMARY OF OPTION ASSESSMENT FOR RAPHOE	38
6.5 SENSITIVITY AND UNCERTAINTY ANALYSIS.....	38
6.5.1 Cost Uncertainty.....	38
6.5.2 Damage Assessment (Benefit uncertainty)	39
6.5.3 Property Threshold Levels	39
6.5.4 Short Duration Rainfall Events.....	39
6.5.5 Combination of Sensitivity Methods.....	40
6.6 RESIDUAL RISK AND SECONDARY MEASURES	40
6.6.1 Hydraulic Modelling of Secondary Measures	42
6.6.2 Walk Over Survey to Assess Secondary Measures Suitability.....	42

6.7	FURTHER ANALYSIS OF THE SECONDARY MEASURES	45
6.7.1	Hydrological Analysis of Secondary Measures.....	45
6.7.2	Meeting with Donegal County Council (20 th August 2015)	47
6.7.3	Walkover Survey.....	47
6.7.4	Outline Design of Secondary Measures	47
6.7.5	Cost Benefit Analysis	49
6.7.6	Assumptions.....	50
6.7.7	Responsibility for the Implementation of Measures	50
7	CONSULTATION AND UPDATING PREFERRED FRM OPTIONS.....	51
8	SUMMARY OF PREFERRED FRM OPTIONS	52

LIST OF FIGURES

Figure 1.1 - Raphoe Overview	8
Figure 1.2 - Optioneering Process	9
Figure 3.1 - Example Social and Cultural Heritage Risk Maps	14
Figure 3.2 - Example Economic Risk Maps	14
Figure 4.1 - MCM's Depth Damage Data for Detached Houses	16
Figure 4.2 - Shapefile with Attribute Table Showing Damage Assessment Data for Buildings at Risk	17
Figure 4.3 - Difficulties in Determining Property Threshold Levels	20
Figure 4.4 - Determination of Property Threshold Level	21
Figure 4.5 - Example Damage Curve	24
Figure 6.1 - Flood Risk Option Development Flow Chart.....	30
Figure 6.2 - Residual Risk after Primary Measure.....	Appendix E
Figure 6.3 - Location of Secondary Measures.....	Appendix E
Figure 6.4 - Primary and Secondary 1% AEP Flood Extent.....	Appendix E
Figure 6.5 - Primary 1% AEP Flood Extent Showing Properties at Risk.....	Appendix E
Figure 6.6 - Location of Refined Secondary Measures	Appendix E
Figure 6.7 - Properties Predicted to be protected by Secondary Measures.....	Appendix E
Figure 6.8 - Area Designated for Further Assessment.....	44
Figure 6.9 - Secondary Measure Catchment Areas.....	46
Figure 6.10 - Proposed Main Drainage Conduits - Arterial Routes A,B,C.....	48

LIST OF TABLES

Table 2.1 - Background Mapping Data.....	11
Table 2.2 - Receptor Data	11
Table 2.3 - Flood Hazard Data	12
Table 2.4 - Survey Data.....	12
Table 2.5 - Economic Assessment Data	12
Table 3.1 - Flood Risk Receptor Groups.....	13
Table 3.2 - Flood Risk Within Raphoe.....	15
Table 4.1 - MCM Property Types	18
Table 4.2 - Categorisation of Properties Data	19
Table 4.3 - Property Threshold Data	21
Table 4.4 - Flood Depth of Properties Data.....	22
Table 4.5 - Converting Pound Sterling to Euro Using the PPP 2010 Values from OECD Website	22
Table 4.6 - Conversion Rates to Current Year Prices Using CPI from CSO Ireland Website	22
Table 4.7 - Flood Damage to Properties Data.....	23

Table 4.8 - Intangible Damages and Emergency Cost Data.....	23
Table 4.9 - AAD and pvD Data.....	25
Table 4.10 - Capping Damages Data.....	25
Table 4.11 - Summary of Damages for Raphoe.....	26
Table 5.1 - List of FRM Options	28
Table 6.1 - Flood Risk Management Applicability Review	31
Table 6.2 - Technical Review of Flood Risk Management Measures	32
Table 6.3 - Summary of Primary and Secondary Options.....	33
Table 6.4 - Environmental and Social Review.....	34
Table 6.5 - Summary of Potential FRM Options to be taken further in the Study	35
Table 6.6 - Additional Costs to FRM Options	36
Table 6.7 - Economic Review of Potential FRM Options	36
Table 6.8 - FRM Options MCA Score Breakdown	37
Table 6.9 - Option Assessment Net Benefit	38
Table 6.10 - Summary of Option Assessment.....	38
Table 6.11 - Sensitivity Test for Excavation Material	39
Table 6.12 - Comparison of Benefit for Differing Threshold Values.....	39
Table 6.13 - Comparison of Differing MCM Flood Duration Damages	39
Table 6.14 - pvD Summary for Short Duration Damages and Property Threshold of 0mm	40
Table 6.15 - Summary of Residual Damage	40
Table 6.16 - Summary of Existing and Residual Risk by Receptor	40
Table 6.17 - Summary of Secondary Measure Pricing	43
Table 6.18 - Final Proposed Secondary Measure Costing	49
Table 6.19 - Economic Damage figures	49
Table 6.20 - Cost Benefit Analysis of Secondary Measures	49
Table 6.21 - Summary of Cost Benefit Analysis.....	50
Table 6.22 - Allocation of Works Relating to The Type of Measure.....	50
Table 7.1 - Record of County Donegal Public Consultation Days.....	51

APPENDICES

APPENDIX A	Flood Risk Maps
APPENDIX B	Potential FRM Options
APPENDIX C	Costing of FRM Options
APPENDIX D	Multi Criteria Analysis
APPENDIX E	Residual Risk Maps and Secondary Measures (Figure 6.2 to 6.7)
APPENDIX F	Secondary Measures - Hydrology Calculations
APPENDIX G	Map of Existing Drainage Infrastructure
APPENDIX H	Proposed Final Secondary Measures to Manage Residual Flood Risk within the Urban Area
APPENDIX I	Proposed Final Secondary Measures - Breakdown of Costs
APPENDIX J	Responsibility for Implementation of Measures

ABBREVIATIONS

AAD	Annual Average Damage
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
BCR	Benefit Cost Ratio
CFRAM	Catchment Flood Risk Assessment and Management
CPI	Consumer Price Index
CSO	Central Statistics Office
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
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
MCA	Multi-Criteria Analysis
MCM	Multi Coloured Manual
MRFS	Mid range future scenario
OPW	Office of Public Works
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 Raphoe Flood Risk Assessment and Management (FRAM) Study in March 2013. A pre-feasibility study was undertaken by Jacobs UK Limited in 2009 which examined flood risk in the town and recommended potentially viable measures for managing the risk. The aim of this FRAM study is to further assess and develop measures to manage existing flood risk in Raphoe town that shall comprise of a feasibility study and preparation of a Flood Risk Management Plan in accordance with the Project Brief (2268/RP/008/A, October 2012). The flood maps produced through the project, and proposed flood risk management measures shall be incorporated into the North-West and Neagh-Bann Catchment Flood Risk Assessment and Management Study which is currently ongoing under the EC Directive on the Assessment and Management of Flood Risks, 2007 (2007/60/EC) as implemented in Ireland by SI 122 of 2010 European Communities (Assessment and Management of Flood Risks) Regulations, 2010.

Raphoe town is located in County Donegal within Hydrometric Area 01. It has a population of approximately 1000. The principal river system in Hydrometric Area 01 is the River Foyle which flows northwards from the confluence of the rivers Finn and Mourne at Lifford and Strabane towns. The Foyle forms the international border between the Republic of Ireland and Northern Ireland, draining the Mourne, Finn and Deele tributaries, discharging into Lough Foyle. As indicated by Figure 1.1 Raphoe is situated on an unnamed tributary which flows into a tributary of the Swilly Burn. The Swilly Burn discharges into the River Foyle approximately 6km north of Lifford/Strabane. The town is surrounded to the north and west by steep sided hills. The small watercourse which runs from north to south through the town from the hillside is predominantly culverted with a catchment area of 4.4 km² where it meets the upper reaches of the Swilly Burn south of Raphoe.

Raphoe has experienced flooding in the past from a combination of fluvial and pluvial flooding, most notably in September 2006 and June 2007.

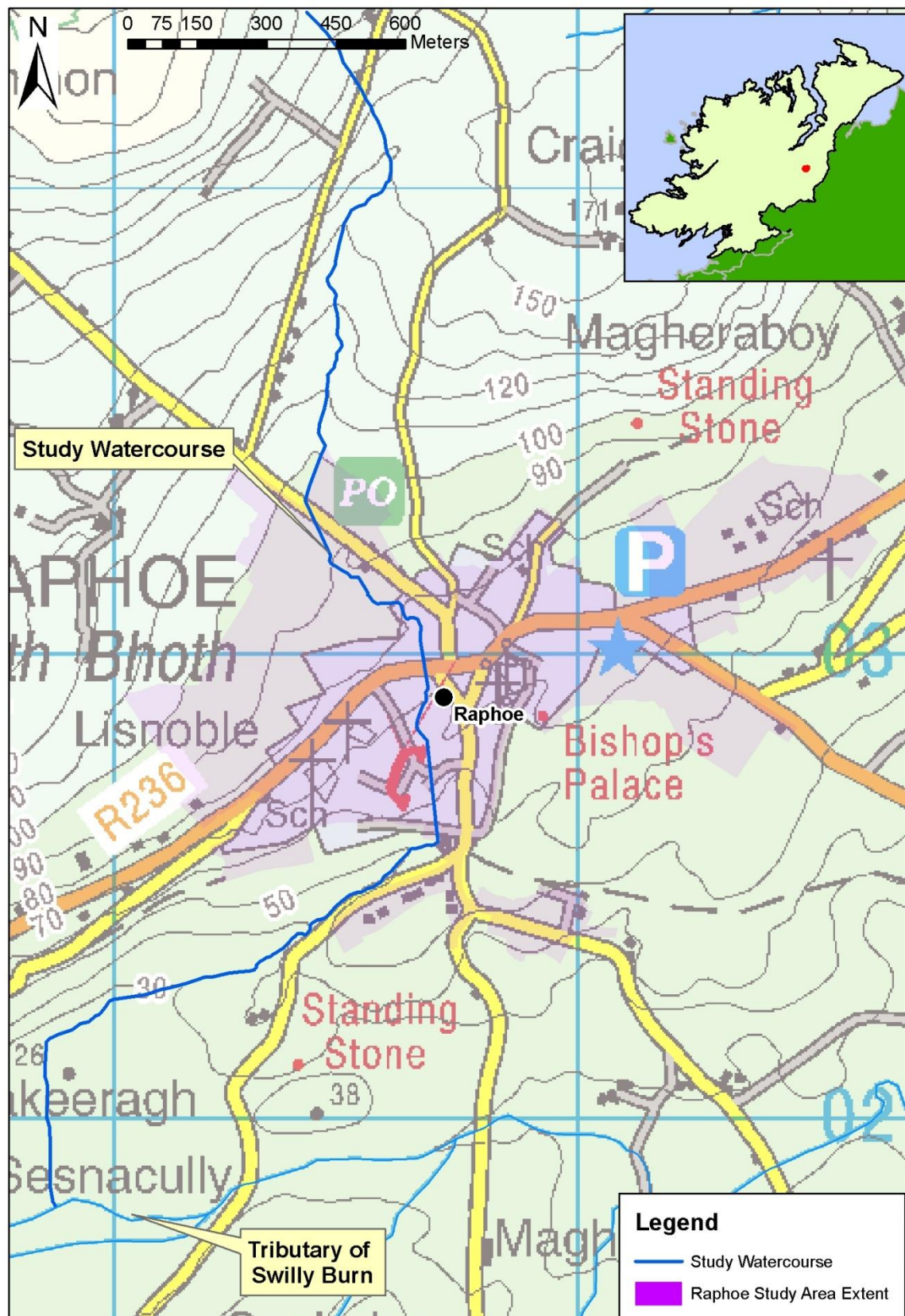


Figure 1.1 - Raphoe Overview

1.1 PURPOSE OF THE OPTIONS REPORT

The main objectives of the options report is to detail the activities associated with Flood Risk Assessment and the development of Flood Risk Management (FRM) Options and to present the outcomes of each.

The report first details the flood risk to the study area 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 study area.

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.

1.2 INTRODUCTION TO THE OPTIONEERING PROCESS

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 1.2.

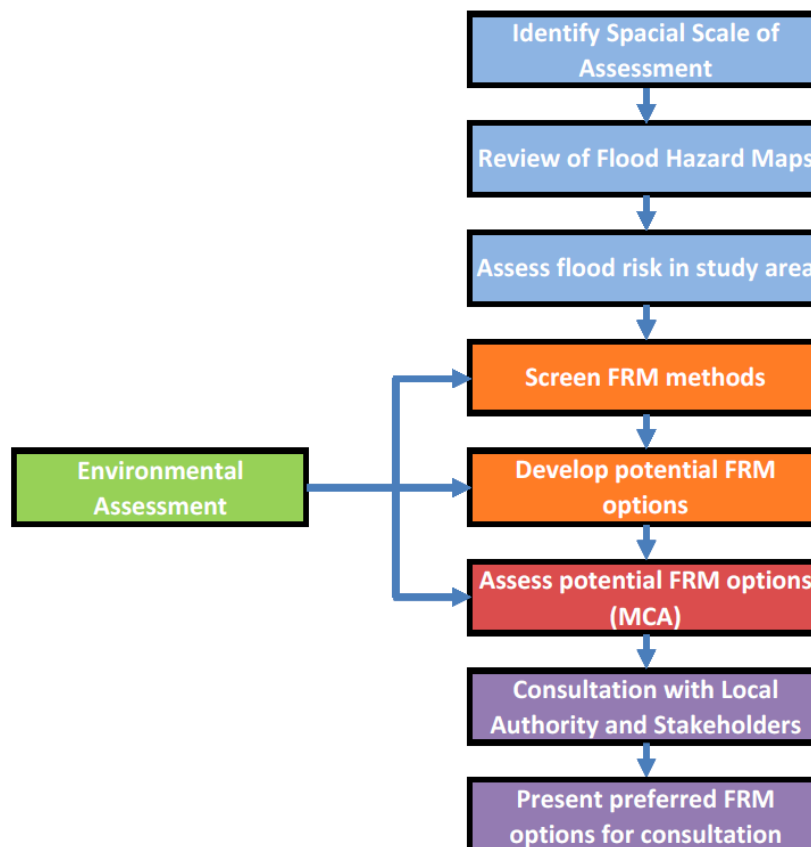


Figure 1.2 - Optioneering Process

The activities shown in the blue boxes in Figure 1.2 identify and assess the flood risk. This is undertaken by establishment of the baseline flooding situation through hydrological and hydraulic analysis to produce a series of flood hazard maps. The flood hazard maps are then used to assess which receptors are at risk and subsequently 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 measures are screened to rule out unacceptable measures. The remaining measures are then developed further and combined to make potential FRM options. This process is described further in chapter 5 and illustrated 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 (red box). These options are then presented for consultation with the OPW, progress group (consisting of local authorities and key stakeholders) and the preferred options identified 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 incorporated if appropriate to produce updated preferred options. This in turn becomes the FRM Measure to be presented in the draft Flood Risk Management Plan (FRMP).

2 DATA COLLECTION

This section details the data used in the optioneering process. The data was received primarily from the OPW, Donegal County Council or produced by RPS through the hydrological and hydraulic analysis activities. Supplementary data was also received from stakeholders and members of the public through the Public Consultation Day held on 26th September 2013. 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 study area 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. Table 2.1 - Background Mapping Data 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
LiDAR, Light Detection And Ranging Map	Various tasks

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 study area.

Table 2.2 - Receptor Data

Data	Use
Primary Schools, Post Primary Schools, Third Level	Flood Risk Assessment
Garda Stations	Flood Risk Assessment
Health Centres	Flood Risk Assessment
Architectural Heritage	Flood Risk Assessment
National Monuments	Flood Risk Assessment
Historical Flood Data	Flood Risk Assessment
OPW Channels	Assessment of FRM measures

Data	Use
River Centrelines	Various tasks
An Post GeoDirectory	Identification of receptors and location of FRM measures

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 measures, developing and assessing potential FRM options. The following datasets were used.

Table 2.3 - Flood Hazard Data

Data	Use
Raphoe 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
Raphoe HEFS (10%, 1%, 0.1% AEP flood events)	Developing FRM options
Raphoe MRFS (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events)	Developing FRM options

2.4 SURVEY DATA

A survey was carried out by Murphy Surveys for the main watercourse which flows through Raphoe. This consisted of surveying river cross sections, and specified structures such as culverts, bridges and weirs. Existing defences were surveyed and their geometric data was also recorded. LiDAR surveys were flown for all relevant areas within the study area providing detail of the topography of the entire town of Raphoe.

Table 2.4 - Survey Data

Data	Use
Channel and Structure survey	Flood Risk Assessment and developing FRM options
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 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 study area 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 adjacent to the receptor and the receptors' vulnerability to flooding.

Table 3.1 - 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-primary, third level education), garda stations, health centres government buildings, local authority buildings.	Location, type and number
	Social amenity sites	
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational Water including bathing water	Location, extent and nature
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places	Location, type and number
Economic	Residential and Commercial Properties	Location, type, number, depth-damage data
	ESB power stations and 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

3.1 FLOOD RISK MAPS

The clearest way to present the flood risk within a study area 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 3.1 below. The economic activity map presents the receptors with a monetary damage according to their type as listed in table 3.1. 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 4. The AAD is represented by the total damage occurring from all receptors in a square grid. An example of Economic Risk Density map is shown in Figure 3.2. The full set of flood risk maps are presented in Appendix A.

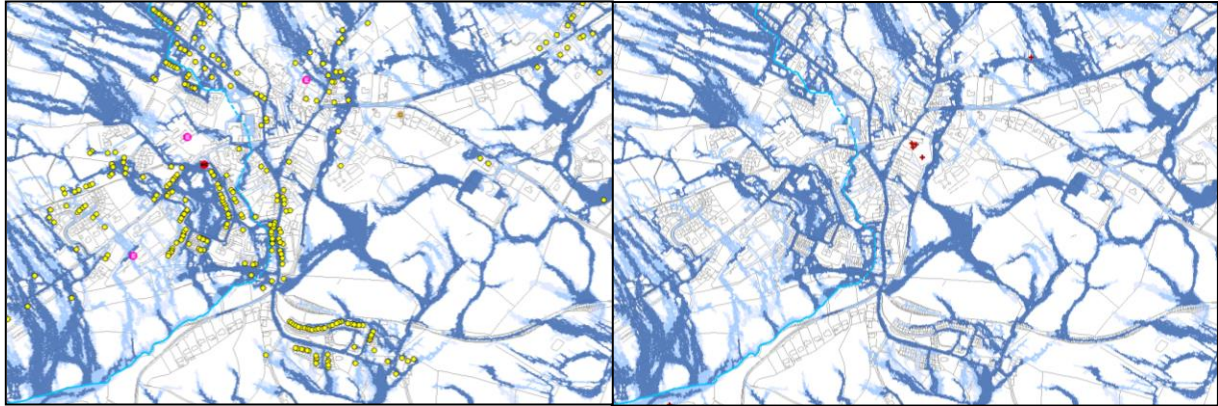


Figure 3.1 - Example Social and Cultural Heritage Risk Maps

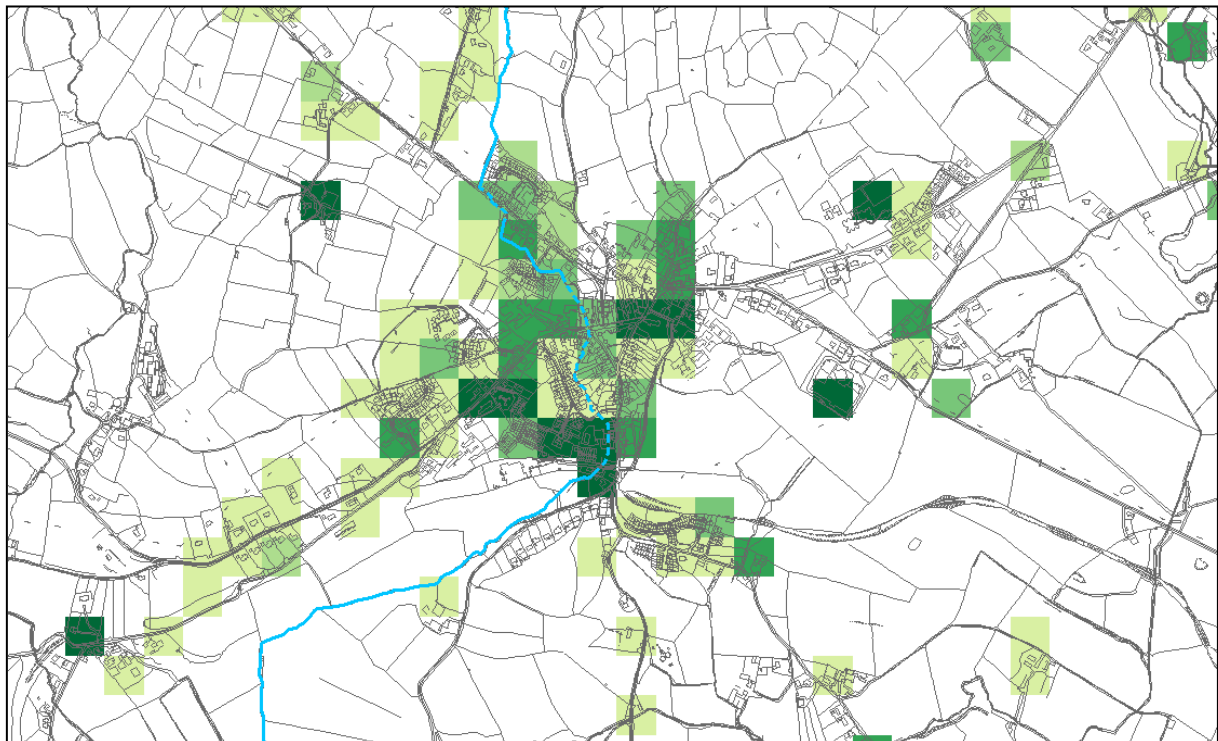


Figure 3.2 - Example Economic Risk Maps

3.2 FLOOD RISK WITHIN RAPHOE

The following table summarises the flood risk to the study area.

Table 3.2 - Flood Risk Within Raphoe

Flood Risk Receptor Group	Receptor	Risk
Social	Residential Properties	237 residential properties are at risk from the 0.1% AEP flood event. 212 residential properties are at risk from the 1% AEP flood event. 126 residential properties are at risk from the 10% AEP flood event.
	Residential Homes (children, disabled, elderly)	None at risk within the 0.1% AEP flood event.
	Schools (primary, post-primary, third level education), garda stations, health centres, local authority buildings.	4 schools are at risk from the 0.1% AEP flood event. 4 schools are at risk within the 1% AEP flood event. 1 schools are at risk within the 10% AEP flood event.
	Social amenity sites	7 playing fields are at varying risk due to flooding in the 10%, 1% and 0.1% AEP flood event.
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational water including bathing water	None at risk within the 0.1% AEP flood event.
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places, UNESCO sites	2 standing stones are subject to the 0.1% AEP flood event. 2 standing stones are subject to the 1% AEP flood event. 1 standing stones are subject to the 10% AEP flood event.
Economic	Residential and Commercial Properties	The total AAD from residential and commercial properties is € 8,481,432.
	ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres	None at risk within the 0.1% AEP flood event.
	Road networks, Rail networks & Stations, Ports and Harbours	None at risk within the 0.1% AEP flood event.

4 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 a study area 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.

4.1 DAMAGE ASSESSMENT GUIDELINES

The damage assessment methodology 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 is a result of 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 4.1 below.

	DETACHED LAND USE CODE 11														
	2010 PRICES														
	FLOOD DURATION MORE THAN 12 HOURS														
Components of damage	DEPTH ABOVE UPPER SURFACE OF GROUND FLOOR														
	-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	0	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 4.1 - MCM's Depth Damage Data for Detached Houses

4.2 RECORDING DAMAGE ASSESSMENT DATA

The damage assessment is carried out in order to quantify the economic risk to the study area. This requires a lot of details to be recorded such as background data, interim calculations and final damage results. As such RPS created several geo-referenced shapefiles with relevant data recorded in their attribute tables, an example of which is shown in figure 4.2. One of the shapefiles created includes building information such as building type, use, area, among other attributes. The buildings shapefile is

presented as polygons. Another shapefile created incorporates attributes such as elevations and depths at building entrances. These building accesses are presented as points.

Two shapefiles created by RPS in order to complete the damage assessment are the buildings shapefile and the join door level shapefile. The building shape file was created to contain background data for building polygons including building type, use, area, among other attributes. The join door level shapefile includes data regarding the doors/entries to all properties, elevation aOD and whether there was a difference between ground level and entry level. From this the Finished Floor Level, FFL, of the property could be calculated. This shapefile was combined with the modelled flood events (**50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP**) to give depths referenced to finished floor level for each flood event. For buildings with multiple entries, the maximum level of water above FFL was taken. These were used to produce a final shapefile showing economic risk of properties relating to a range of flood events.

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 Raphoe study produced a shapefile detailing the economic risk to all properties called "H01RE_Blds_Q1000_Ex_JD_long" quantified as total AAD and total pvD. These will be summarised at the end of section 4.

Total AAD	Total pvD
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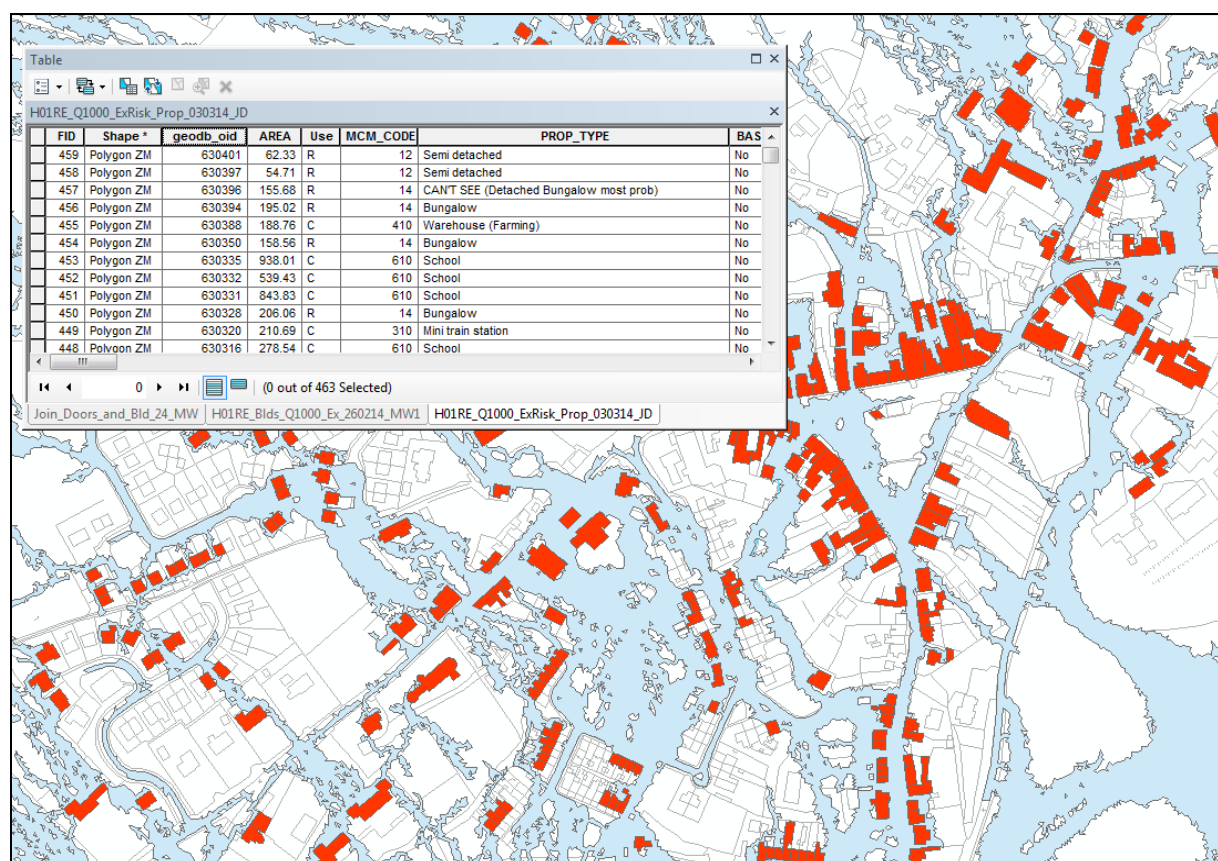


Figure 4.2 - Shapefile with Attribute Table Showing Damage Assessment Data for Buildings at Risk

4.3 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 4.1 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 4.1 - 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
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
Laundrette	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

Property Type	MCM code	Property Type	MCM code
		Cemetery/Crematorium	930
		Bus Station	940
		Dock Hereditament	950

For Raphoe 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 buildings polygon shapefile attribute table:

Table 4.2 - Categorisation of Properties Data

Data type	Attribute name	Data details
Property ID	geodb_oid	An Post geo-directory database ID
Location	"Et_X" and "Et_Y"	X Y coordinates to Irish National Grid
Floor Area or 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 Raphoe 0.1% AEP flood extent there was a total of 345 residential and commercial properties.

4.4 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 most properties are constructed with the floor level raised 300mm above the adjacent ground level. This would be particularly characteristic of fluvial or coastal floodplains which are generally low lying and flat in nature. In Raphoe the predominant source of flooding emanates from surface water runoff, generally as a result of convective type rainfall events common to the summer months. This type of flooding is exacerbated by the fact that the town itself is surrounded by elevated ground and falls steeply from its northern to southern boundary. A characteristic of surface water flooding is that it is generally fast flowing and of low depth, therefore the determination of finished floor levels with a good degree of accuracy is essential in determining the number of properties which are actually at risk. The steep topography also has an influence on finished floor levels whereby some properties have split level front doors and back doors and some properties enter at ground level but have basements below. The standard approach of adding 300mm to the average of the surrounding ground level could potentially produce some erroneous results. Figure 4.3 provides an example of how the steep topography could result in an inaccurate assessment of threshold levels.

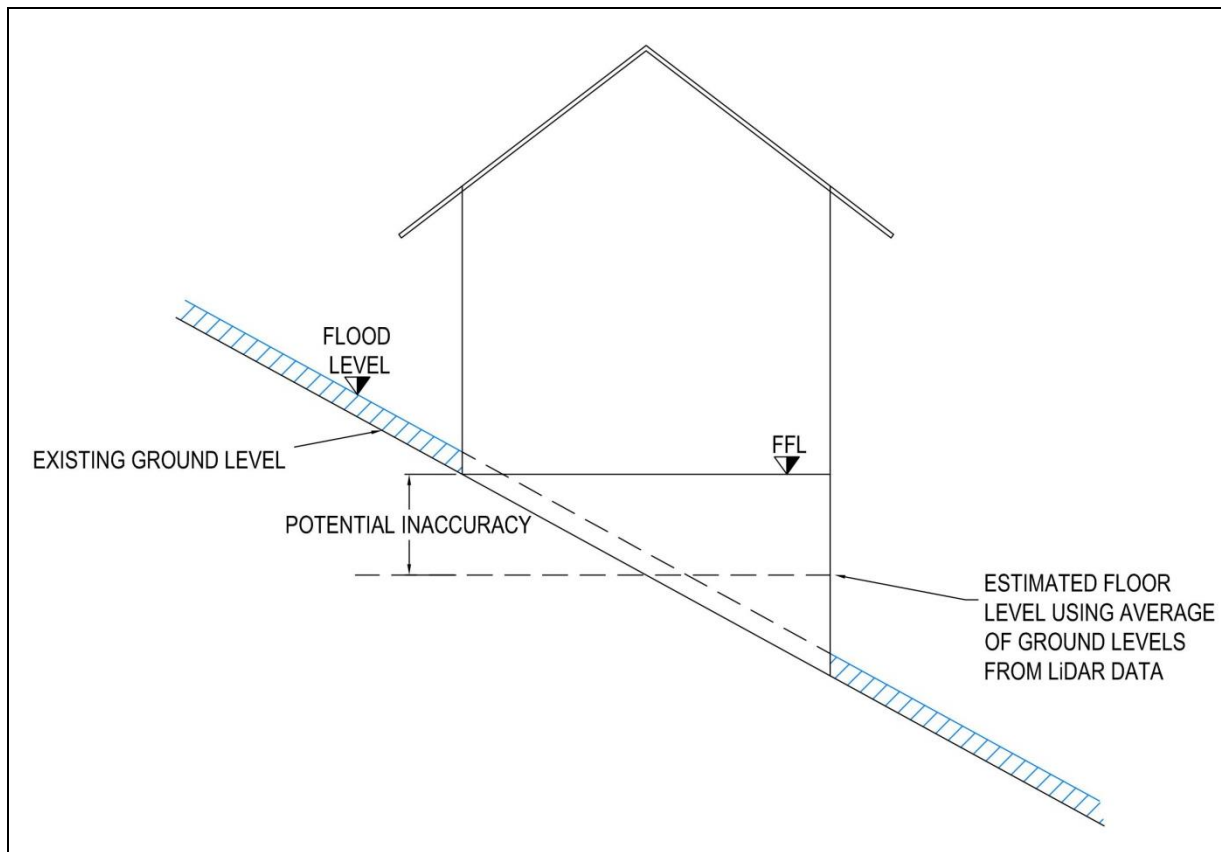


Figure 4.3 - Difficulties in Determining Property Threshold Levels

To improve the accuracy in the assessment of threshold levels RPS have undertaken a number of exercises in this regard. These are detailed below:

A review of each property initially using Google Street view and Bing maps and a walkover check survey to establish front and back door locations.

Classification on the entrance type to each property:

- Raised = +200mm for every step above LiDAR defined ground level (where 2 more steps exist).
- Normal = +300mm above LiDAR defined ground level.
- Flat = LiDAR defined ground level taken as threshold level.
- Lowered = -200mm for every step down below LiDAR defined ground level.

A final chosen threshold level was assigned to each property by taking the worst case of the predicted flood level at both the front and back door locations.

Figure 4.4 provides a graphical depiction of this methodology.

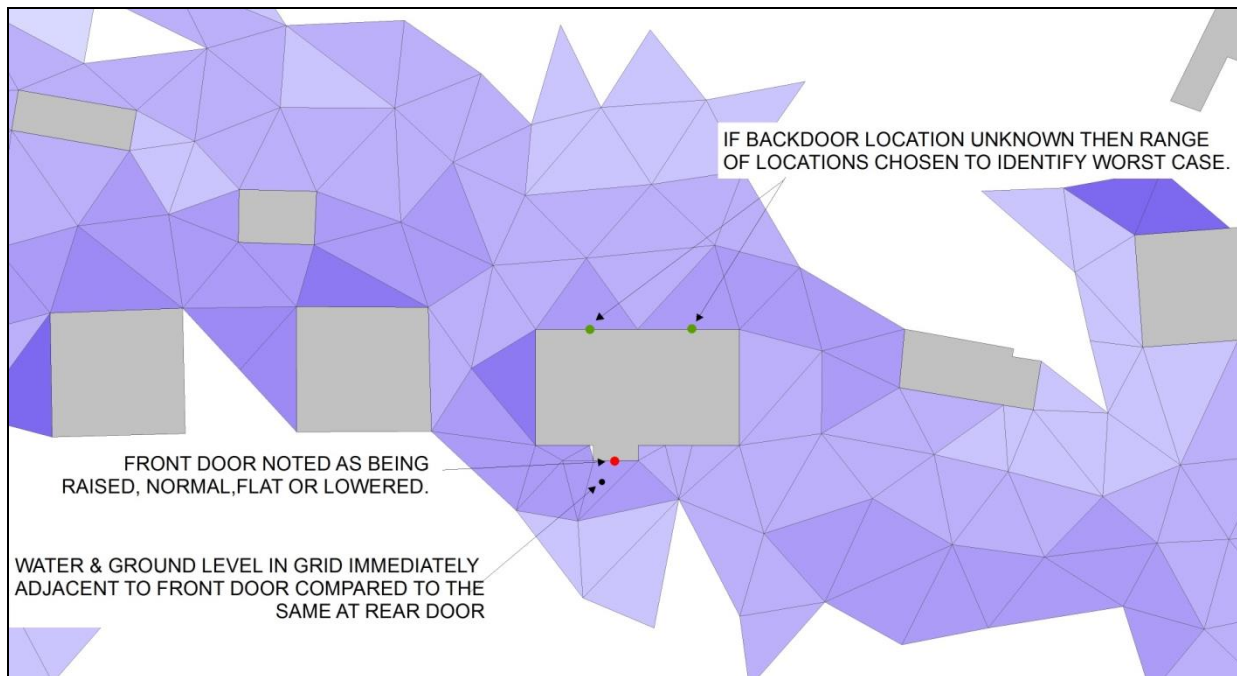


Figure 4.4 - Determination of Property Threshold Level

The details described in Table 4.5 were recorded within the economic risk shapefile attribute tables against each property:

Table 4.3 - Property Threshold Data

Data type	Attribute name	Data details
Basement present?	BASEMENT	"Yes" means basement present, "No" means no basement
Is ground floor raised	RAISED	"Level" ground floor is level. "Normal" ground floor is raised by 300mm. "Raised" ground floor level is raised by 200mm for every step above LiDAR defined ground level (where 2 more steps exist) "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 Level	FFL	Ground level plus 0.3m for properties without basement, ground level minus 2.5m for properties with basement

4.5 FLOOD DEPTH OF PROPERTIES

To estimate the damage to a property an estimation of the predicted flood depths is required for a wide range of flood events. The Project Brief requires the depths to which the properties flood during the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events to be calculated. The depth of flooding is calculated by finding the difference between the flood water elevation and the estimated threshold level (as described in section 4.4). To achieve this, the maximum flood depth at each property is required. It is recognised that as flood water passes around a building the water levels will vary and, specifically characteristic to the surface water flooding in Raphoe, flood depths can be low and potentially only affect a property should they flow directly into a doorway. To maintain a conservative approach the maximum flood level adjacent to either the front or back door of the property (as described in section 4.4) was extracted and recorded in the attribute table of the economic risk shapefile. This process was achieved by carrying out a statistical analysis in ArcGIS

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 4.4 - Flood Depth of Properties Data

Data type	Attribute name	Data details
Flood level for all flood events	Q1000Elv, Q200Elv, Q100Elv, Q50Elv, Q20Elv, Q10Elv, Q5Elv, Q2Elv	The maximum flood level adjacent to the building (mOD)
Flood depth for all flood events	Q1000Dp, Q200Dp, Q100Dp, Q50Dp, Q20Dp, Q10Dp, Q5Dp, Q2Dp	Difference between the flood level and FFL

4.6 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. These direct damage figures have been updated to 2010 pound sterling prices and are based on the square metre of the floor area of the building, an example of this data is present in Figure 4.1. 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 Raphoe FRAM Study was 1.345, the conversion rates are shown below.

Table 4.5 - 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 4.6 - Conversion Rates to Current Year Prices Using CPI from CSO Ireland Website

CPI	
2006	100
2010	101.2
Apr-13	106.4
2010 - 2013	1.051383

The following details the information and calculations described above which were recorded within the damage assessment shapefile attribute tables:

Table 4.7 - Flood Damage to Properties Data

Data type	Attribute name	Data details
Direct damage per meter square	Q1000_M2Dm, Q200_M2Dm, Q100_M2Dm, Q50_M2Dm, Q20_M2Dm, Q10_M2Dm, Q5_M2Dm, 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, Q2_Dm£10	Damage per meter square multiplied by floor area of building.
Damage conversion to euro and 2013 prices	1000_Dm€13, Q200_Dm€13, Q100_Dm€13, Q50_Dm€13, Q20_Dm€13, Q10_Dm€13, Q5_Dm€13, Q2_Dm€13	Conversion rate (1.345) applied to damage to property over full floor area.

4.7 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 assign 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 was carried out to identify these small businesses and an intangible damage equal to the direct damage was also assigned to the property.

A cost will be associated with emergency services dealing with the flood events. Following the EA'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 details in Table 4.8 were recorded within the economic risk shapefile attribute tables:

Table 4.8 - Intangible Damages and Emergency Cost Data

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

Data type	Attribute name	Data details
	Q20_emerg, Q10_emerg, Q5_emerg, Q2_emerg	

4.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE

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). The AAD can then be taken over the lifetime of the study that has been set at 50 years and discounted back to present day costs. This present day discounted cost is known as present value damage (pvD).

The AAD can best be described by considering the graph shown in Figure 4.5. The points shown represent the various design 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. The area under the curve is therefore a function of the damage and the frequency and gives the AAD. The events that were considered for this study were the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events.

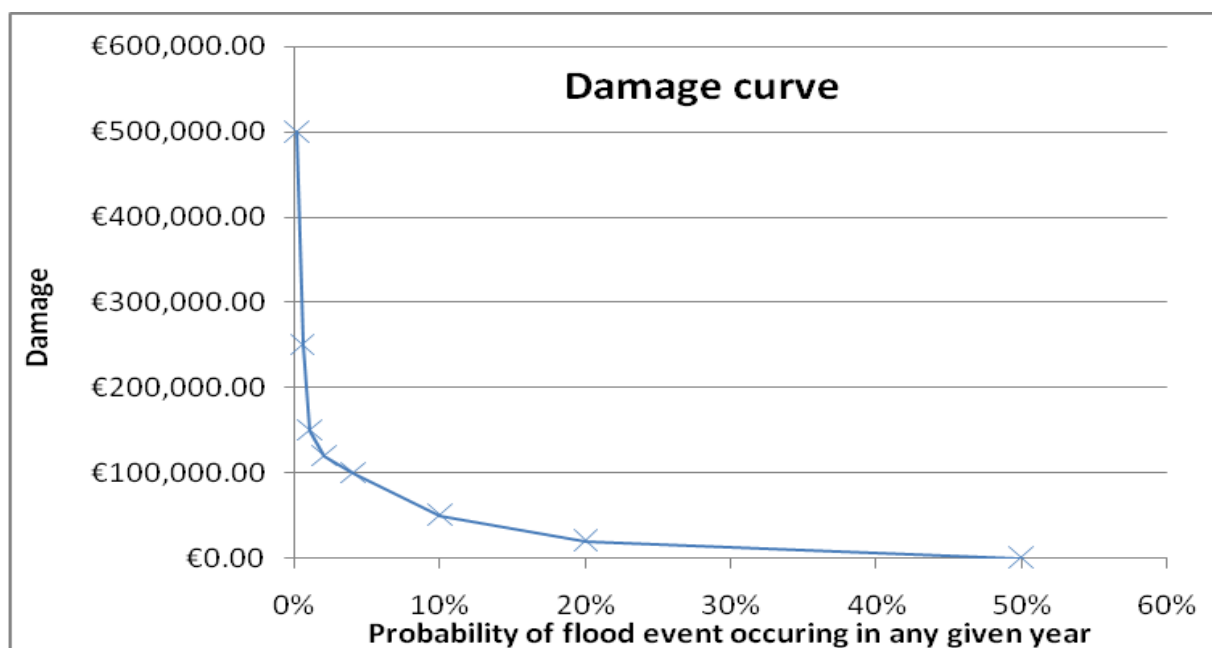


Figure 4.5 - Example Damage Curve

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. The discount rate to be used on public projects is set centrally by the Department of Public Expenditure and reform at 4% and has been implemented in this study. Over the 50 year lifetime being considered, this amounted 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 measures to alleviate this risk the standard of protection will usually be the 1% AEP flood event. The following details were recorded within the economic risk shapefile attribute tables:

Table 4.9 - AAD and pvD Data

Data type	Attribute name	Data details
Annual Average Damage for direct damages, intangible damages and emergency costs	AAD, AAD_Int, AAD_emerg,	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, pvD_Int, pvD_emerg,	The AAD factored by 22.341

4.9 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 using market data sourced from the CSO. The area chosen was 'other areas' as to not include National, Dublin, Cork, Galway, Limerick and Waterford to give a more accurate representation for prices in rural Ireland. Quarter 2 of 2013 was chosen as this is when the works began. An average of the mean 'new house prices' and mean 'second hand house prices' was taken to give a value of €189,664. 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 in Table 4.10 were incorporated within the economic risk shapefile attribute tables:

Table 4.10 - Capping Damages Data

Data type	Attribute name	Data details
Capped damages for direct and intangible	pvD_Cap, pvDInt_Cap,	Damages over €189,664 are capped at this value

4.10 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.

4.11 SUMMARY OF DAMAGES IN RAPHOE

The last field, CapVal, 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 Raphoe.

Table 4.11 - Summary of Damages for Raphoe

Total AAD	Total pvD
€8,481,432	€22,453,691

4.12 LIMITATIONS OF THE FLOOD DAMAGE ASSESSMENT

Within any study of this nature there is always uncertainty which needs to be accounted for in the overall analysis. This emanates from a variety of sources including standard errors in datasets, limitations of computer modelling and lack of historical data of sufficient accuracy. This has been recognised by RPS and a number of modifications have been incorporated into the hydraulic model and subsequent flood outlines to provide greater accuracy in the above calculation of AAD. These include:

- Removed all areas showing flooding less than 10mm depth as the model is not calibrated to this accuracy.
- Removed all isolated areas of flooding less than 200m² as in reality these are unlikely to contribute to damage to property and will be dealt with by existing drainage systems.
- All roads were dropped by 100mm to ensure the model correctly simulated flow between kerbs.
- 50% AEP rainfall profile removed from all hydrographs to better reflect that taken by the drainage network.

Even with these additions to improve accuracy, a figure in excess of €8m would be considered to be a very high value for AAD and could be reflective of applying standard methodologies to what are very unique flooding mechanisms in Raphoe. In reality the comprehensive sensitivity analysis (detailed in Section 6.5.2 of this report) and some of the lower figures of AAD generated from it may provide a more accurate assessment.

5 FLOOD RISK MANAGEMENT MEASURES

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

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

The Raphoe FRAM 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 Study Area. With this being said it is an aspiration of the study to provide the highest standard of flood risk management. This would, in general, entail providing 'protect' measures over 'prepare' measures and avoiding 'permit' measures where possible. 'Prevent' measures should always be included as they consider future flood risk.

5.1 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 measures provide. The preferred design standard for this study is the 1% AEP event for pluvial 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, then measures below the preferred design standard may be considered.

5.1.1 Residual Risk

For any FRM measure the flood risk to a study area can never be totally eliminated as a flood event greater than the design standard can occur. This is referred to as residual risk. The preferred design standard for Raphoe is the 1% AEP event. It can therefore be assumed there will be residual damage for the 0.5% and 0.1% AEP flood events. A further consideration to Raphoe is that some of the assumptions made within the hydraulic modelling approach make the exact quantification of residual risk difficult. Due to the lack of information on the existing drainage network an assumption was made whereby the capacity of the existing drainage network was originally ignored then assumed to cater for only the 50% AEP rain fall event (refer to Raphoe Hydrology / Hydraulics Report, IBE0809Rp0001, Section 4.6 for details). This means that flood extent maps are conservative and subsequently the need for FRM measures in certain areas may be questionable. Furthermore, once FRM measures are proposed, the model will still simulate rainfall falling behind these defences and potentially identify areas of flooding which in reality maybe dealt with by the drainage network. This could lead to defences or measures being proposed in locations where they may not be required.

For the purposes of this study it is assumed that for FRM measures that contain the flow within the river channel, such as flood walls, the residual damage for flood events greater than the design standard will be the same as the present day current damages. For FRM measures 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.

5.2 LIST OF FRM MEASURES

Table 5.1 - List of FRM Options

FRM Method	Method type	Description
Do Nothing	Permit	Implement no new flood risk management measures and abandon any existing practices.
Maintain Existing 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.
Land Use 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 Development 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 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 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 Channel Conveyance	Protect	Deepening of channel bed, widening of channel, realigning long section profile, removal of constraints, lining or smoothing channel.

FRM Method	Method type	Description
Hard Defences	Protect	Reinforced concrete walls, earth embankments, demountable barriers.
Relocation of Properties	Protect	Abandoning flood risk area and properties within and providing alternative properties in more suitable areas.
Culverting	Protect	Routing the watercourse underground via a culvert to prevent out of bank flooding along a specific stretch.
Diversion of Flow	Protect	Removing flow from the watercourse or intercepting surface water runoff via a diversion and discharging to a suitable location, river or coastline. This may consist of a culvert or an open channel.
Overland Floodways	Protect	Using topographical features of the floodplain to convey out of bank or surface water flow and discharge to other suitable rivers, the coast line, further downstream on the same river or to an open area for storage. 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 Existing Defences	Protect	Improvement of existing flood defences.
Localised Protection Works	Protect	Minor raising of existing defences/levels, infilling gaps in defences, etc.
Flood Warning/Forecasting	Prepare	Installation of flood forecasting and warning system and development of emergency flood response procedures.
Public Awareness 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 Protection	Prepare	Flood protection and resilience measures such as flood gates, vent covers, use of flood resilient materials, raising electrical power points, etc

Each measure has been reviewed against its applicability for Raphoe and those which are obviously unsuitable were removed.

5.3 BASELINE CONDITION

The FRM method "maintain existing regime" is considered the baseline condition as described in Table 5.1 above. This represents the current scenario which all other scenarios, created by the implementation of other FRM measures, are compared to. This is realised by the reduction in receptors at risk, as described in chapter 3, and the reduction in monetary damage (see chapter 4) also known as benefit.

6 ASSESSMENT OF FRM MEASURES

The development of FRM options for Raphoe will follow the flow chart as defined in Figure 6.1. This process has been developed to demonstrate that all feasible measures have been considered and that suitable justification has been provided by those measures which have been included and also those which have been rejected.

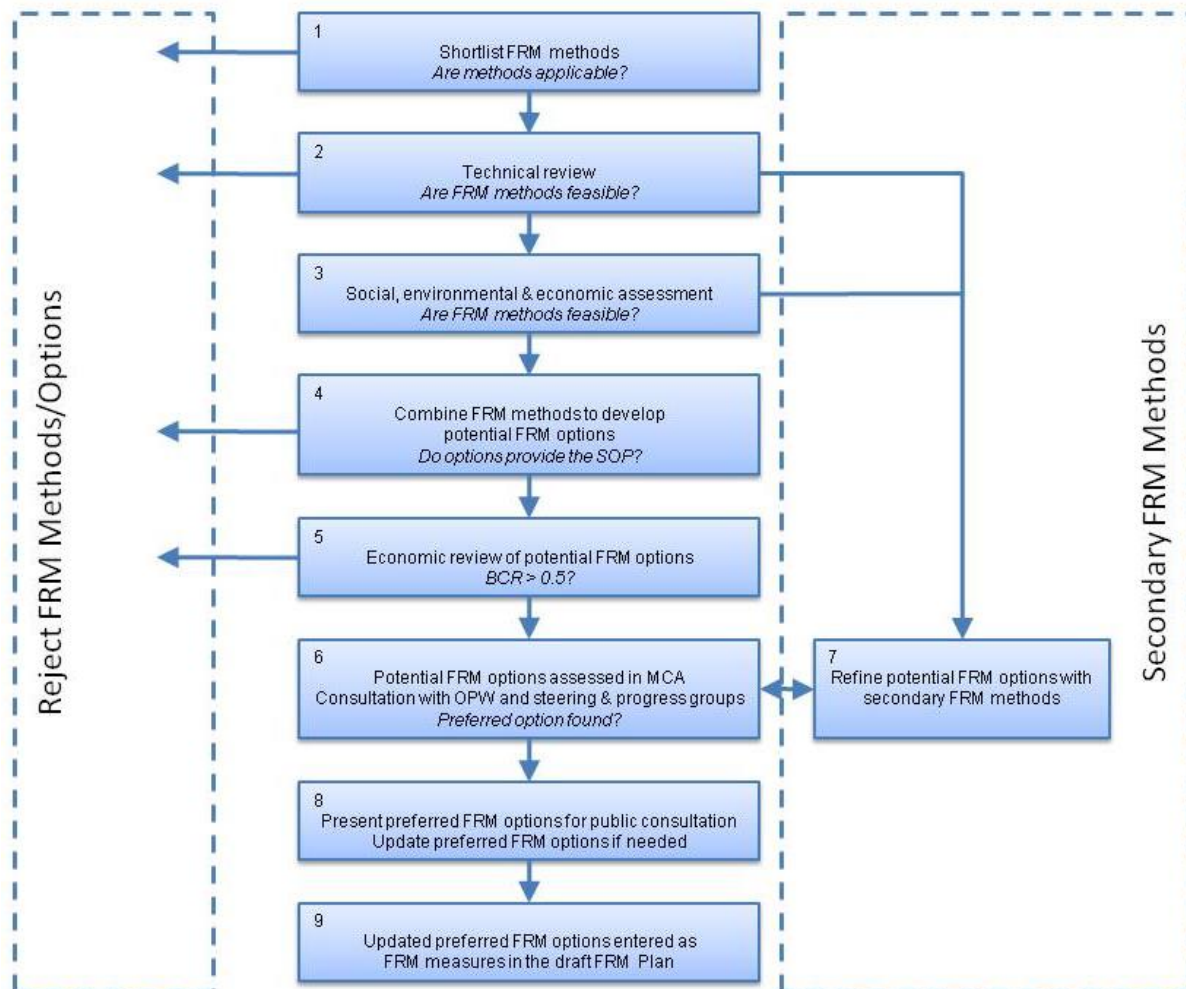


Figure 6.1 - Flood Risk Option Development Flow Chart

The flow chart summarises in boxes 1 to 3 how the screening of FRM measures is carried out. Boxes 4 and 5 describe how the feasible FRM measures 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. If however no preferred FRM option is identified, box 7 shows how the options can be refined with additional or other FRM measures 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.

6.1 SCREENING FLOOD RISK MANAGEMENT MEASURES

The aim of the screening process is to ensure the widest possible range of FRM measures are considered in the assessment process while the rejection of any measures shall be robust and with clear and transparent reasoning. The long list of measures in Table 5.2 are consistent with those being proposed on the OPW CFRAM projects but have been reviewed to ensure the unique flooding mechanisms that exist in Raphoe can be accounted for.

6.1.1 Applicability Review of FRM Measures

All measures which have been considered as applicable are then reviewed on their technical merits and their ability to alleviate the specific mechanisms of flooding that exist in Raphoe. This is based on engineering judgement, information from local engineers, feedback from the Public Consultation Day, flood mapping and reviewing animations of model output.

Table 6.1 - Flood Risk Management Applicability Review

Measure	Review comment	Applicable?
Do Nothing	Consider further	Yes
Maintain Existing Regime	Baseline Condition. Consider further	Yes
Do Minimum	Consider further	Yes
Planning and development control	Consider further	Yes
Building regulations	Consider further	Yes
Catchment wide SuDS	Consider further	Yes
Land use management	Consider further	Yes
Strategic Development Management	To be considered at UoM and Sub-Catchment SSA	Yes
Maintenance programme	Consider further	Yes
Upstream storage/storage	Consider further	Yes
Tidal barrage/flap valve	Not applicable based on Raphoe's Geographical Location	No
Improvement of channel conveyance	Consider further	Yes
Hard defences	Consider further	Yes
Relocation of properties	Consider further	Yes
Culverting	Consider further	Yes
Diversion of flow	Consider further	Yes
Overland floodways	Consider further	Yes
Rehabilitation of existing defences	Only existing defences are in the vicinity of Frankie's nightclub and are recently constructed and in good condition. Measure unacceptable	No
Localised protection works	Consider further.	Yes
Flood warning/forecasting	Consider further	Yes
Public awareness campaign	Consider further	Yes

Measure	Review comment	Applicable?
Individual property protection	Consider further	Yes
Sealing manholes	Consider further	Yes

6.1.2 Flooding Mechanisms

Before undertaking a technical review of the applicable FRM Measures, RPS carefully considered the flood mechanisms which exist in Raphoe. This was imperative to ensure that all proposed FRM measures considered the correct source and flow path of each flooding mechanism.

Historical flood events and animations of modelling outputs have identified that during significant or intense rainfall events, surface water runoff flows rapidly from the steep agricultural catchment to the north and west. This is exasperated by minimal infiltration occurring in the catchment due to high bedrock level which is evident at different locations above the town, and at times sediment run off from arable fields as advised by local residents at the draft mapping PCD. As the runoff reaches the town the roads and streets act as conduits collecting the flows from the hillside and conveying the flow to almost all areas of the town. As a consequence there are few properties which are not inundated by flooding to some degree or at least have access to their properties affected. Figure 3.3 in Appendix E shows in more detail the sources and flow paths identified from the 1% AEP event modelling output which was used in the technical review of the applicable FRM Measures.

6.1.3 Technical Review of FRM Measures

Measures which have technical merit will be divided into two categories; primary and secondary. Primary measures are those which will be considered as having a reasonable likelihood of providing the required standard of protection, to the majority of properties at risk from a 1% AEP event. Secondary measures may have some technical merit and could solve some localised flooding issues but will only address flooding to a small number of properties at risk during the 1% AEP event.

This approach ensures that the primary measures will be prioritised for consideration with the opportunity to add in the shortlisted secondary measures to resolve localised issues. Addition of secondary measures may be implemented after consultation at a detailed design stage, or be revisited in the future to address more localised issues.

Table 6.2 - Technical Review of Flood Risk Management Measures

FRM Measure	Comment	Applicable?
Do Nothing	Due to the existing flood risk in the Raphoe area the Do Nothing FRM method is deemed unacceptable socially and economically.	✗
Maintain Existing Regime	This measure is to be kept as the baseline condition.	✓
Do Minimum	Will not solve all flooding issues therefore consider further as secondary measure.	▶
Planning and Development Control	Study will inform Planning and ensure consistency with National Planning Guidelines for Flood Risk Management. Consider further as secondary measure.	▶
Building Regulations	Could inform a recommendation to a nationwide approach to flood resilience. Consider further as secondary measure.	▶
Catchment wide SUDS	Implementing SUDS in the catchment may assist with alleviating localised flooding and could solve flooding issues to a small number of properties, but is unlikely to provide a large scale benefit to Raphoe. This measure has therefore been considered as a secondary option.	▶
Land Use Management	Review of agricultural practices in lands immediately above Raphoe has proven to reduce the rate of run-off for low return events but will only have localised benefit and a minimal impact during the design return period. Consider further as a secondary measure.	▶

FRM Measure	Comment	Applicable?
Strategic Development Management	No strategic development is envisaged for Raphoe that would require this measure.	✗
Maintenance Programme	Existing maintenance programme has been influenced by recent flood events and is important to minimise risk from smaller rainfall events. Will be required regardless of the chosen option. Measure can continue through screening process as a secondary option.	►
Upstream Storage/Storage	Agricultural land in the catchment lends itself to providing the space required for temporary storage of storm water. Measure can continue through screening process as primary measure.	✓
Improvement of Channel Conveyance	Will not resolve all flooding issues. Consider further as secondary measure.	►
Hard Defences	Measure can continue through screening process as primary measure.	✓
Relocation of Properties	Will not be possible to relocate all properties affected but potentially could alleviate flooding to an isolated property/ies. Consider further as secondary measure.	►
Culverting	Will not resolve all flooding issues. Consider further as secondary measure.	►
Diversion of Flow	Measure can continue through screening process as primary measure.	✓
Overland Floodways	Measure can continue through screening process as primary measure.	✓
Localised protection works	Measure may only help localised flooding and will not provide the preferred design standard of protection, therefore consider further as a secondary measure.	►
Flood Warning/Forecasting	Nature of critical rainfall is generally convective and very difficult to predict the intensity or exact location. Times to inundation are < 1hr so would have minimal impact. Measure unacceptable.	✗
Public Awareness Campaign	Will not resolve all flooding issues. Consider further as secondary measure.	►
Individual Property Protection	Will not resolve all flooding issues. Consider further as secondary measure.	►
Sealing Manholes	Will not resolve all flooding issues. Consider further as secondary measure.	►

These primary and secondary measures have been summarised in Table 6.3.

Table 6.3 - Summary of Primary and Secondary Options

Primary Measure	Secondary Measure
Maintain Existing Regime	Do Minimum
Upstream storage/storage	Planning and development control
Diversion of flow	Building regulations
Hard defences	Retro-fitted SUDS
Overland floodways	Land use management
	Maintenance programme
	Improvement of Channel Conveyance
	Relocation of Properties
	Culverting
	Public awareness campaign
	Individual property protection
	Sealing manholes
	Upstream storage/storage*

Primary Measure	Secondary Measure
	Diversion of flow*
	Hard defences*
	Overland floodways*

*Primary measures can also be implemented to alleviate localised flooding to small number of properties, therefore can also be considered as secondary measures.

6.1.4 Environmental and Social Review

It is important to ensure that measures 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 review is assessed from environmental, social/cultural and economic criteria in turn.

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

- The methodology must be robust and defensible;
- The methodology must be rapid and replicable;
- The methodology must be precautionary to avoid rejecting measures 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, upstream or downstream of the proposed method and subject to a clear and negative impact from the method, it 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 measures which have not been flagged in terms of environmental, social or cultural impacts first. As there are no SACs, SPAs or Unesco sites within the catchment in consideration all of the primary and secondary measures can pass through to the next stage of screening. This is confirmed in Table 6.4.

Table 6.4 - Environmental and Social Review

	Measure	Review comment	Continue?
1.	Maintain Existing Regime	FRM Measure can continue through screening process	✓
2.	Upstream Storage/Storage	FRM Measure can continue through screening process	✓
3.	Diversion of Flow	FRM Measure can continue through screening process	✓
4.	Hard Defences	FRM Measure can continue through screening process	✓
5.	Overland Floodways	FRM Measure can continue through screening process	✓

6.2 DEVELOPING POTENTIAL FRM OPTIONS

The primary FRM measures which have progressed through the technical, environmental and social screening have been combined to create potential FRM options for Raphoe. Most measures, while providing significant reductions in flood risk, will not manage the flood risk entirely by themselves. Measures are therefore required to be combined into options so that they will manage the flood risk and achieve the objectives set by the study. All possible combinations of FRM measures have been considered as potential FRM options; however, only options that can provide the required design standard are progressed further.

6.2.1 Further Technical Analysis of Primary Measures to Produce Potential FRM Options

It was apparent from the draft mapping public consultation day and the walkover surveys undertaken by RPS, that substantial flood risk management solutions within the town would be unfeasible given the narrow streets and the subsequent constraints they present to construction work. Instead, it was decided that focussing on options outside the town with an emphasis on storage and diversion would provide the primary option. RPS therefore developed three potential options for Raphoe from the list of primary measures presented in Table 6.4. These options are presented in Table 6.5 with a short description of each option provided below. Plan drawings of all three options are provided in Appendix B.

Table 6.5 - Summary of Potential FRM Options to be taken further in the Study

Potential FRM Options	
1.	Diversion of Flow, Overland Floodways
2.	Hard Defence, Diversion of Flow, Overland Floodways
3.	Hard Defences, Storage, Overland Floodways

A brief description of what each FRM option will encompass has been included below.

Option 1 - Diversion of surface water flow originating from the hills to the north and west of Raphoe by the creation of an open channel to collect and divert flows away from the town. Earth embankments from the excavated channel will be created on the lower side of the channels to provide freeboard and prevent overtopping. Diverted flow will be directed to existing river channels to the south-west and south-east of the town respectively. A plan drawing of Option 1 is provided in Appendix B.

Option 2 - Similar to option 1, this arrangement will intercept runoff from the hills to the west of Raphoe and direct it towards the existing watercourse to the south-west of Raphoe. Runoff originating from the hills to the north will be intercepted in a similar manner and diverted to existing watercourse to the south-east. Instead of an open channel this option considers the use of a reinforced wall/channel to collect and divert the flow away from the town. A plan drawing of Option 2 is provided in Appendix B.

Option 3 – Differs from option 1 and 2 in that instead of diverting surface water flow from the hills it considers the possibility of creating storage areas to the north and west of the town. These structures will need to be constructed from reinforced concrete as the storage depths exceed 5m such that earth embankments with the standard gradients for front and rear facing slopes would minimise the area available for storage. The reinforced concrete structures will intercept and store water for a short period of time before releasing the water in a controlled manner both during and after the rainfall event. A plan drawing of Option 3 is provided in Appendix B.

6.3 ASSESSMENT OF POTENTIAL FRM OPTIONS

The 3 potential FRM options which have progressed to this stage have been found to be technically, socially, environmentally feasible. In order to ascertain the preferred option for Raphoe, each option must be considered against a range of criteria and objectives to determine the optimum solution. This is undertaken by scoring each option against the following three criteria to provide an overall score for each:

- **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.

6.3.1 The Benefit Cost Ratio (BCR)

The BCR is a simple calculation of the whole life cost of a FRM option against damage avoided over the same time period. The estimation of damages has been described in detail in Chapter 4 of this report and the method for the estimation of costs is described as follows.

The cost of constructing FRM measures has been calculated using data from OPW, Local Authorities, the UK Environment Agency and RPS. This data is based on previous schemes using real costs. This data is presented as rates to be applied to the FRM measures depending on the quantities involved.

As such the first stage in this process was to quantify the FRM measures. This information included wall lengths and heights, volume of embankments, etc. This was carried out by hydraulic modelling and using the GIS software ESRI ArcMap. The location and extent of FRM measures were delineated in GIS using OSi mapping with consideration of the flood risk receptors. Once finalised the design standard flood event was simulated with each FRM method incorporated within the hydraulic model and the heights required calculated. Once the heights have been calculated, the construction rates can be applied to estimate the cost. Drawings of these options are included in Appendix B

Costs additional to those for construction were included to give a complete estimate of the overall cost of the option. Table 6.6 lists the additional provisions that were included.

Table 6.6 - Additional Costs to FRM Options

Item	% of construction cost
Provision for unmeasured items	20
Provision for optimism bias	60
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

Maintenance of any FRM options has been accounted for by factoring 1% of the construction cost by 21.48 to give the NPV maintenance cost over a design life of 50 years.

6.3.1.1 Estimation of BCR Ratio

Based on the methodology set out in Section 6.3.1, costs for the three potential options have been calculated and compared to the damage avoided. This is summarised in Table 6.7.

Table 6.7 - Economic Review of Potential FRM Options

Option	Benefit	Residual Damage	Construction and Additional Costs	BCR
1	€ 12,273,611	€10,180,080	€895,297	13.71
2	€ 12,273,611	€10,180,080	€29,721,228	0.41
3	€ 12,273,611	€10,180,080	€61,727,420	0.20

With each of the three primary options there is a considerable amount of residual damage still occurring within the town itself. This occurs because although the FRM options divert the majority of the flow away from the town, rain is still falling directly onto the urban area (effectively behind the defences) in sufficient quantities to continue to cause damage to properties. This is discussed in more detail in Section 6.6 when considering potential secondary FRM measures.

6.3.2 The Multi-Criteria Analysis (MCA) Methodology

The assessment of FRM options in the past has been primarily based on economic costs and benefits, with an Environmental Impact Assessment 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, which 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.

6.3.2.1 MCA of Potential FRM Options

Based on the methodology set out in 6.3.2 the results of the MCA are presented in Table 6.8. The MCA evaluation sheets providing the breakdown of scoring for each option are provided in Appendix D.

Table 6.8 - FRM Options MCA Score Breakdown

	Option 1	Option 2	Option 3
Technical score	800	600	200
Economic score	210	210	180
Social score	150	150	150
Environmental score	60	55	30
Overall score	1220	1015	560

It can be seen that all three options achieved the same social scores as well as similar economic scores. This is due to each option providing a similar level of protection to relevant indicators such as residential and commercial properties. The economic score was less for Option 3 due to the size of the storage areas required being prohibitively expensive. The associated depths of water stored also were also substantial and would present a significant risk to life should they fail. On the technical criteria Option 1 has the highest score due to the low risk associated with the basic, low risk construction methods involved in excavating an embankment. Options 2 and 3 involve retaining wall structures which include piling, deeper excavations and heavy plant which brings about a slightly higher risk to workers. On the environmental score option 1 again achieved the highest score. This accounted for the reduced impact on landscape character and visual amenity involved with less intrusive earth embankments, compared to retaining walls.

6.3.3 Overall net benefit methodology

The overall net benefit is a ratio used to demonstrate the relevant overall benefits of each option. It is accepted that for an option to proceed it must be cost-beneficial in its own right, but it is a method by which a numerical score can be assigned to give an indication of the overall or net benefit of each option. To calculate the net benefit the MCA score is divided by the whole life cost of the scheme.

6.3.4 Net Benefit Scores

Based on the methodology described in section 6.3.3 the overall net benefit scores are detailed in Table 6.9.

Table 6.9 - Option Assessment Net Benefit

FRM Options	Whole Life Cost (€Ms)	MCA Score	Net Benefit
Option 1	€0.895	1220	1362.7
Option 2	€29.721	1015	34.2
Option 3	€61.727	560	9.1

6.4 SUMMARY OF OPTION ASSESSMENT FOR RAPHOE

The analysis of the three criteria described in the previous section has fully assessed each of the preferred primary options. Table 6.10 presents the complete scoring for each of the three FRM options.

Table 6.10 - Summary of Option Assessment

FRM Options	BCR	MCA Score	Net Benefit	Overall Ranking
Option 1	13.71	1220	1362.7	1
Option 2	0.41	1015	34.2	2
Option 3	0.20	560	9.1	3

It is clear from the above table that Options 2 and 3 are not economically viable as well as being more environmentally damaging from a visual and aesthetic point of view. Therefore Option 1 is considered to be the preferred primary option. Appendix B includes a map illustrating an indicative cross section of the preferred primary option. This cross section is an approximation for illustrative purposes and will require refinement at the detailed design stage, should the option be taken forward.

6.5 SENSITIVITY AND UNCERTAINTY ANALYSIS

6.5.1 Cost Uncertainty

At this stage of the design process for any flood alleviation scheme there is a degree of the construction costs associated within the preferred option, in that no ground investigation services enquires have been undertaken. In particular bed rock is anticipated to be relatively surface as it is visible on the hills above Raphoe. RPS undertook a sensitivity analysis on the option allowing for varying proportions of rock and topsoil being encountered and their effect on the overall BCR. The results of this sensitivity testing are presented in

Table 6.11. It can be seen that even in the worst case excavation of 50% rock still provides an overall BCR of 8.36. This provides assurance that the BCR is robust regardless of the ground conditions encountered.

Table 6.11 - Sensitivity Test for Excavation Material

Topsoil/Rock Excavated (%)	Construction and Additional Costs	Benefit	BCR	Favourable
100/0	€ 817,432	€ 12,273,611	13.71	✓
10/90	€ 921,941	€ 12,273,611	12.15	✓
20/80	€ 1,026,450	€ 12,273,611	10.92	✓
50/50	€ 1,339,978	€ 12,273,611	8.36	✓

6.5.2 Damage Assessment (Benefit uncertainty)

Many of the predicted flood depths within Raphoe are low and there is relatively little historical flooding information of sufficient accuracy to provide good calibration data. Relying on just hydraulic modelling results in this circumstance would not be recommended and therefore it is essential that comprehensive sensitivity testing is undertaken to ensure the estimated BCR is robust. Subsequently RPS varied a number of the parameters within the damage assessment to test the robustness of the preferred option.

6.5.3 Property Threshold Levels

The threshold levels for each property were estimated using the methodology described in Chapter 4 of this report using the best available information. There still remains some uncertainty on their exact level and therefore RPS considered varying the property threshold level by 300mm as a sensitivity test on the overall cost benefit ratio. Essentially this is equivalent to assessing damages at threshold level as opposed to the standard practice of 300mm below threshold level. Table 6.12 indicates that although this substantially reduces the overall BCR it still indicates a positive BCR of 9.68.

Table 6.12 - Comparison of Benefit for Differing Threshold Values

Threshold value (mm)	Damages pvD (Existing)	Damages pvD (Primary Option)	Benefit	Construction and Additional Costs (100%Topsoil Excavation)	BCR
-300	€22,453,691	€10,180,080	€ 12,273,611	€895,297	13.71
0	€14,583,620	€6,466,448	€8,117,172	€895,297	9.07

6.5.4 Short Duration Rainfall Events

An alternative approach used to calculate damages outlined in the MCM for 'short duration' flooding was carried out. This can be applied in areas where times of inundation of properties are limited, and assigns reduced damages when compared with the damages associated with long duration flooding. The MCM defines long duration as water depths above ground floor level for more than 12 hours, with short duration relating to water depths above floor level for less than 12 hours. This approach, although appropriate to the type of flooding experienced by Raphoe in previous events, comes with a warning that the damage figures derived in the MCM have been based on a relatively small dataset and that the long duration is still the recommended approach. With this in mind, this approach was used as a sensitivity test to provide a lower boundary for damages incurred to ensure a favourable BCR is still achieved. Table 6.13 indicates that although this substantially reduces the overall BCR it still indicates a positive BCR of 11.32.

Table 6.13 - Comparison of Differing MCM Flood Duration Damages

Duration of Inundation	Damages pvD (Existing)	Damages pvD (Primary Option)	Benefit	Construction and Additional Costs (100%Topsoil)	BCR
------------------------	------------------------	------------------------------	---------	---	-----

				Excavation)	
Long	€22,453,691	€10,180,080	€ 12,273,611	€895,297	13.71
Short	17067124	7476904	€9,590,220	€895,297	10.71

6.5.5 Combination of Sensitivity Methods

Due to the uncertainties discussed in the previous two sections regarding the property threshold levels and damages relating to short duration events, it was decided to combine these two approaches for Raphoe. This conservative approach will provide absolute assurance that the preferred option is definitively cost beneficial despite the uncertainties identified. The results of this analysis are presented in Table 6.14 below. The BCR has been reduced further, although still shows a positive BCR of 8.99.

Table 6.14 - pvD Summary for Short Duration Damages and Property Threshold of 0mm

Damages pvD (Existing)	Damages pvD (Primary Option)	Benefit	Construction and Additional Costs (100%Topsoil Excavation)	BCR
€13,184,781	€5,574,392	€7,160,389	€895,297	8.00

6.6 RESIDUAL RISK AND SECONDARY MEASURES

As discussed in section 6.3.1.1 even with the primary option in place there are still significant residual damages occurring in the town from rain falling behind the defences. Table 6.15 summarises the benefit and residual risk of the preferred primary FRM measure.

Table 6.15 - Summary of Residual Damage

AEP Event	Present Value Damages	Benefit of Preferred FRM	Revised pvD due to AEP Event
1%	€22,453,691	€ 12,273,611	€10,180,080

Figure 6.2 in Appendix E shows the extent of residual flooding including the properties still deemed at risk (-300mm threshold level and above) from an event of this magnitude. The table below provides a comparison between the receptors currently identified at risk from various AEP events and those that may still be at risk with the primary measures in place.

Table 6.16 - Summary of Existing and Residual Risk by Receptor

Flood Risk Receptor Group	Receptor	Existing Risk	Residual Risk With Primary Measure in Place
Social	Residential Properties	237 residential properties are at risk from the 0.1% AEP flood event. 212 residential properties are at risk from the 1% AEP flood event. 126 residential properties are at risk from the 10% AEP flood event.	177 residential properties are at risk from the 0.1% AEP flood event. 134 residential properties are at risk from the 1% AEP flood event. 67 residential properties are at risk from the 10% AEP flood event.
	Residential Homes (children, disabled, elderly)	None at risk within the 0.1% AEP flood event.	None at risk within the 0.1% AEP flood event.

Flood Risk Receptor Group	Receptor	Existing Risk	Residual Risk With Primary Measure in Place
	Schools (primary, post-primary, third level education), garda stations, health centres, local authority buildings.	4 schools are at risk from the 0.1% AEP flood event. 4 schools are at risk within the 1% AEP flood event. 1 school is at risk within the 10% AEP flood event.	2 schools are at risk from the 0.1% AEP flood event. 2 schools are at risk within the 1% AEP flood event. 1 school is at risk within the 10% AEP flood event.
	Social amenity sites	7 playing fields are at varying risk due to flooding in the 10%, 1% and 0.1% AEP flood event.	7 playing fields are at varying risk due to flooding in the 10%, 1% and 0.1% AEP flood event.
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational water including bathing water	None at risk within the 0.1% AEP flood event.	None at risk within the 0.1% AEP flood event.
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places, UNESCO sites	2 standing stones are subject to the 0.1% AEP flood event 2 standing stones are subject to the 1% AEP flood event 1 standing stones are subject to the 10% AEP flood event	1 standing stones are subject to the 0.1% AEP flood event 1 standing stone is subject to the 1% AEP flood event 1 standing stone is subject to the 10% AEP flood event
Economic	Residential and Commercial Properties	The total AAD from residential and commercial properties is € 8,481,432	The total AAD from residential and commercial properties is € 6,529,504
	ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres	None at risk within the 0.1% AEP flood event.	None at risk within the 0.1% AEP flood event.
	Road networks, Rail networks & Stations, Ports and Harbours	None at risk within the 0.1% AEP flood event.	None at risk within the 0.1% AEP flood event.

As a further step to focus on the areas which had the most significant risk, RPS produced a flood depth or “heat” map with small incremental depth bandings in order to highlight specifically those areas with the greatest associated damages. The intention of this map is to prioritise those areas where secondary measures are most likely to be required. Additionally only properties which actually have a flood depth greater than their estimated threshold levels were highlighted as being at risk. This is a justifiable approach as the fast flowing and short duration nature of the flooding may not affect the subfloors of properties in the same manner that more standard fluvial or coastal flooding would. This map is presented in Figure 6.3 in Appendix E. It was evident from Figure 6.2 and Figure 6.3 that a number of secondary measures within the town were going to be required to deal with the identified residual risk. The full range of secondary measures initially being considered is presented in Figure 6.4 in Appendix E. A table providing a brief description of each option is also included.

6.6.1 Hydraulic Modelling of Secondary Measures

RPS re-simulated the model with a number of secondary measures included but the results did not have the desired outcome. These measures were primarily the storage and defence options located in the fields immediately above the town but also included minor works within the town itself. The model results indicated that although the measures were having an effect by altering flow paths and lowering flood depths, they were only reducing the number of properties at risk by a small amount. On further investigation, flow paths were being cut off but were starting again almost immediately on the defended side of the measure. This was initially at very small depths but quickly escalated to similar depths as before. Upon further consideration it was determined that many of these flow paths had depths less than 150mm which was now approaching the level at which confidence in the accuracy of the model outputs is questionable. Especially when considering the accuracy of the data used to build the model, hydraulic parameters chosen and hydrological inputs. In particular:

1. Domestic and the public drainage networks are not included in the model although an allowance has been made for what they could potentially convey (assumed they can deal with 50% AEP rainfall). In certain locations the drainage network is likely to convey more than this and subsequently some of the flow paths maybe overestimated.
2. There are known drainage ditches and channels within the town which may not fully replicate flow paths.
3. Threshold levels have been estimated from the LiDAR data with some alteration to improve accuracy as discussed in section 4.4.
4. Kerb lines, walls, fences or in fact any structure on the ground which could alter flow paths are unlikely to be within the model.
5. Standard error in the LiDAR data.
6. Chosen roughness values become more significant at these depths.
7. Allowance for infiltration is not included within the model.
8. There is very little calibration data of sufficient quality for either flood depths or from rain gauging.

Given the potential magnitude of residual risk and the uncertainties identified with the hydraulic model at this resolution, further analysis was required to assess the need for the proposed secondary measures. Following consultation with the OPW and Donegal County Council it was determined that a walkover survey with key staff who had experienced some of recent flood events was a necessity.

6.6.2 Walk Over Survey to Assess Secondary Measures Suitability

A walk over survey was undertaken in July 2014 by RPS, the OPW and Donegal County Council Engineers. The purpose of this visit was to:

- Discuss the secondary options proposed, locate them on the ground and apply engineering judgement to the model outputs.
- Make adjustments to the lengths, areas and location of all measures to take advantage of natural features.
- Review the appropriateness of the proposed measures and remove those which were deemed no longer required due to recently undertaken work or geographical features which have not been included within the model.
- Identify areas for further investigation where engineering judgment on the information available was not deemed to be an acceptable approach to determining whether a measure is required or not.

During the walk over survey it was agreed that the model extents were accurate and the majority of the measures were agreed to have potential in providing localised protection against flooding mechanisms identified in previous flood events. This was particularly true of storage and attenuation measures proposed in open areas above the town. It was agreed as a general consensus that once storm water gets into the town it is very difficult to deal with, due to the restriction of scope for diversion or storage, as well as properties having doorways directly onto pavements which limits space for any construction works. In a number of key locations several sections of culvert were proposed to deal with known flood routes where the lack of conveyance was known to be a significant issue. An example of this was in the McBride Street area extending to the open drain adjacent to the

castle. The result of this exercise is presented in Figure 6.6 in Appendix E where the updated, proposed secondary measures and locations of the arrangements is provided. Estimated indicative whole life costs for each of these options are provided in Table 6.17.

Table 6.17 - Summary of Secondary Measure Pricing

Measure	Description	Project Whole Life Cost* (including maintenance)
1	Increase size of existing ditch to increase conveyance.	€10,600.00
2	Culvert beneath road to take flow from measure 1 away from property entrance and front garden.	€5,700.00
3	Create new ditch to convey flow from measure 2.	€1,100.00
4	Culvert to connect new ditch (measure 3) and the existing ditch along Castle Grove (measure 5).	€5,800.00
5	Existing ditch along Castle Grove, to be increased in size and directed into the proposed storage area between Castle Grove and Mongorry Close (measure 14).	€4,400.00
6	Head wall to direct any overflow from a new culvert inlet (measure 7) towards the storage area (measure 14).	€24,900.00
7	Culvert inlet upgrade.	€1,500.00
8	New culvert under road to convey flow from the watercourse to a new open channel.	€7,300.00
9	Culvert outlet into new open channel.	€1,500.00
10	New open channel.	€2,700.00
11	Culvert inlet (Restricted).	€1,500.00
12	Culvert to connect with existing watercourse.	€5,400.00
13	Culvert outlet.	€1,500.00
14	Embankment to provide storage and attenuation.	€1,647,200.00
15	Earth embankment to create a storage area beside Castle Road. This is intended to store floodwater from Castle Road before naturally releasing it.	€828,400.00
16	Storage ditch/embankment intended to provide storage, reducing the amount of runoff from the areas above making its way into the town.	€3,040,900.00
17	Ditch to divert flow around the Royal and Prior Comprehensive school on the Derry Road.	€5,000.00
18	Storage ditch to protect property and stop flow from reaching the road.	€3,000,300.00
19	Storage ditch to stop runoff from reaching the road.	€2,296,200.00
20	Ditch to divert floodwater around commercial space.	€8,500.00
21	New culvert where old stone culvert is identified to have collapsed and is not fit for purpose.	€62,600.00
22	Storage embankment along the field alongside Guesthouse End to store runoff that was previously allowed to flow onto Guesthouse End and Carnowen Road.	€755,600.00
23	Wall to divert water around St. Eunan's school.	€40,200.00

Measure	Description	Project Whole Life Cost* (including maintenance)
24	Road reprofile to direct any runoff from the road or water that has overtopped the new culvert inlet and head wall into storage area in the field beside Castle Grove.	€71,700.00
25	Road reprofile to intercept runoff from the road into the proposed storage area created by a new embankment (measure 15).	€18,200.00
26	Landscaping of field to allow water to be conveyed to the proposed storage area along the lower boundary of the field.	€7,200.00
27	Road reprofile to naturally convey water off the main road.	€26,300.00
28	Lower existing lane to convey water away from the main road and properties into agricultural land.	€63,600.00
29	Road reprofile to divert water into the storage area created by measure 18.	€11,800.00

*Additional costs used to calculate whole life cost include Unmeasured items (20%), Optimism bias (60%), Detailed design (6%), Construction Supervision (5%), Allowance for Archaeological and/or environmental monitoring/exploration (21%), Cost of land acquisition/compensation (12.5%), Allowance for art (1%)

There was one area of the town where there was considered inadequate information to quantify the extent of the secondary measures required. This was to the west of the Diamond as shown in Figure 6.2.

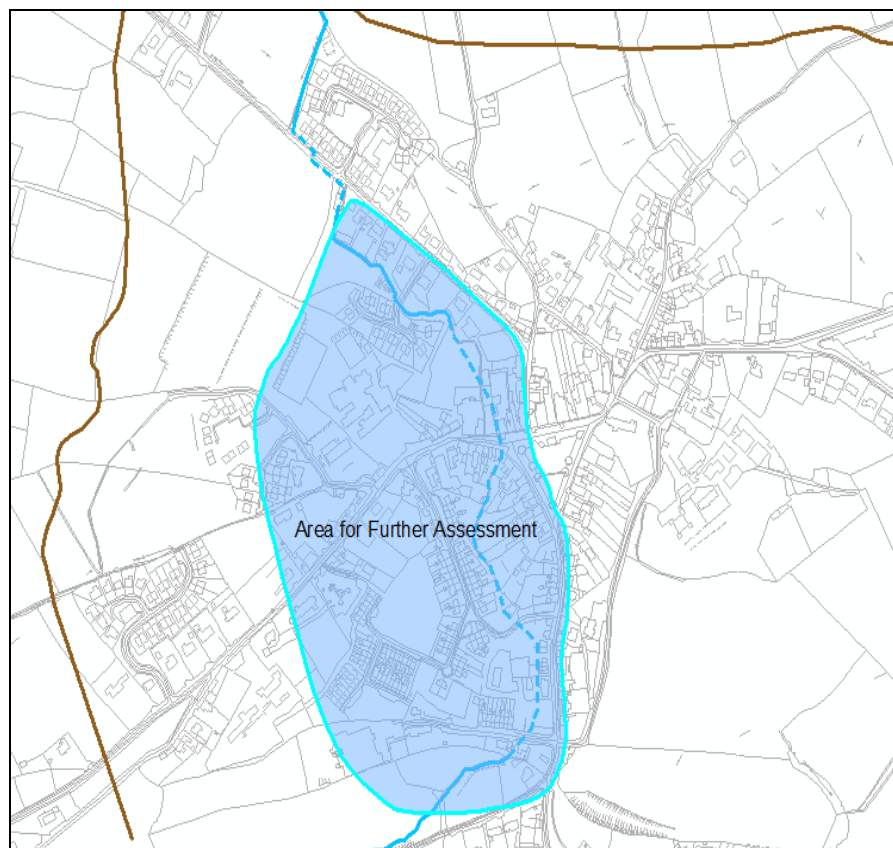


Figure 6.8 - Area Designated for Further Assessment

In this area it was agreed by all that while the modelled flood routes correlated well with historical flooding events, there was too much uncertainty as to whether the proposed secondary measures would still be necessary with the proposed primary measures in place. It was felt that given the reduction in flows from the primary measures the existing drainage network may have capacity to

manage the residual flows without further modification. Further analysis was subsequently undertaken as detailed in Section 6.7.

6.7 FURTHER ANALYSIS OF THE SECONDARY MEASURES

Following the initial description and indicative costing of the secondary measures it was agreed that further work should be undertaken to achieve greater certainty from both a technical and cost aspect in relation to the proposed secondary measures. It was agreed the following steps would be taken to achieve this:

- 1.) A review of the peak flows and total volumes of rainwater the secondary measures would be required to deal with;
- 2.) A site visit to examine local drainage, defences and flow paths to robustly justify the costs for any secondary measures in the urban area;
- 3.) Consideration of whether road drainage should be able to manage residual/excess flows;
- 4.) Critical review and refinement of secondary measures including costs and benefits;
- 5.) Recommendation for the OPW's information on the organisation that is most appropriate to implement the remaining proposed secondary measures.

6.7.1 Hydrological Analysis of Secondary Measures

The peak flows and total volumes of rainwater for each of the secondary measures were assessed. This was completed using hydrological design estimation methods (refer to Raphoe FRAM Study Hydrology and Hydraulics Report (IBE0809Rp0001_F01) for details) and compared to the values extracted from the model outputs. Refer to Appendix F for hydrological calculations for secondary measures.

There are two types of secondary measure proposed; storage measures which are generally in undeveloped areas above the town; and conveyance measures which include drainage infrastructure and measures to divert flow away from property.

In the case of the storage measures the total volume and depth are the critical factors in the design whereas with the conveyance measure the peak flow is the critical parameter.

To calculate the volume of each storage measure the catchment area specific to the measure was estimated. From this and using the hydrological methods employed in the aforementioned hydrology and hydraulics report a flow volume in cubic metres for the design event was calculated. The volume calculated was the total rain falling onto the entire catchment for the design event.

Within the model the storage measures allow the rainfall to build up behind each of the measures. The volume of water retained behind the measure was extracted from the model outputs. The maximum depth of retained water at the measure was also extracted from the model outputs.

The volumes from both methods were compared and the difference between the hydrology method and the model outputs was found to be within 12% for three storage areas and approximately 20% for two storage areas. The hydrology method was always higher as it calculates the total rain that falls within the catchment, whereas the volume extracted from the model was that stored behind the measure at the max water elevation. However this comparison indicates that the model is well anchored to the hydrological estimates.

To calculate the peak flow of each of the conveyance measures the catchment area specific to the measure was estimated. From this and using the hydrological methods employed in the aforementioned hydrology and hydraulics report a peak flow for the design event was calculated. These peak flows were used to help size the conveyance measures.

As the conveyance measures were not incorporated into the model the overland flows were dispersed throughout each of the catchments and therefore the peak flows for measures could not be extracted accurately from the model outputs. However due to the good correlation between the hydrology estimated volumes and the model volumes the hydrology estimated flows can be used with confidence even though they cannot be extracted from the model. Figure 6.9 indicates the catchment areas that were used to assess the flows and volumes and the quantities that were estimated.

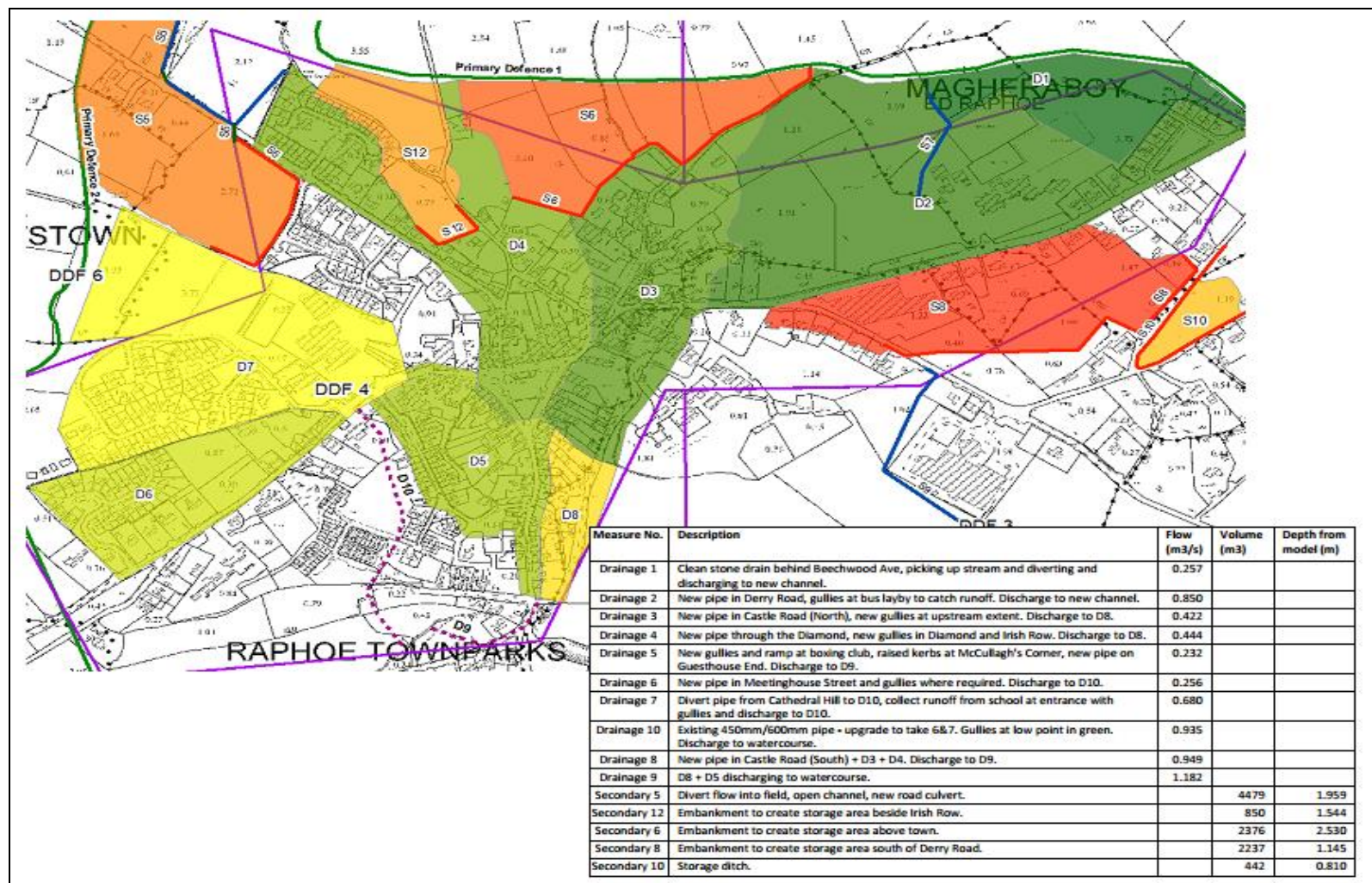


Figure 6.9 - Secondary Measure Catchment Areas and Volumes

6.7.2 Meeting with Donegal County Council (20th August 2015)

RPS prepared a drainage record drawing detailing all known existing storm and combined pipes within the urban area. This was based on all information collated previously as part of the Jacobs pre-feasibility study in 2009 and during the course of the current study. This drawing was presented at a meeting with Donegal County Council Engineers to allow them to review all of this information on a single drawing. As stated in Section 6.6.1 of this report the hydraulic model does have limitations in assessing the residual risk and therefore the purpose of the meeting was to readily identify any obvious omissions or errors regarding existing drainage infrastructure. It also sought to draw out any areas of the drainage network which were known to be problematic or alternatively which may have additional capacity to deal with the predicted residual risk.

A number of key omissions were identified by Donegal County Council Engineers and corrections to the maps were made. Appendix G shows the map presented to Donegal County Council and also the corrections and points of additional information highlighted to RPS at the meeting. Donegal County Council staff also agreed to attend a walkover survey to clarify the route of some of the piped network and review some of the predicted flooding mechanisms with a view to assisting in the outline design of flood alleviation measures.

6.7.3 Walkover Survey

RPS, OPW and DCC undertook a walkover survey on 23rd and 24th August 2015 to review the route of existing piped drainage infrastructure and the modelled residual flood risk outlines and flooding mechanisms. The intention of this exercise was to establish how realistic the predicted low depth flood outlines were, to see if in reality they may be confined to the road network and/or affected by localised changes in topography including garden walls, kerbs or ramps which may in fact protect some of the properties identified as being at risk. One of the key aspects of this walkover was to determine how to get the predicted surface water flows into the sub-surface drainage network especially given that standard road gullies are unlikely to be able to convey the predicted flows. These two days on site combined with the hydraulic modelling output provided the basis for the outline design of the secondary measures described as follows.

6.7.4 Outline Design of Secondary Measures

Based on the walkover survey and hydraulic model outputs, a suite of secondary measures were proposed to deal with the residual risk identified with the primary measures in place. All of the proposed measures are based on the hydraulic modelling and its limitations listed in Section 6.6.1 of this report but verified through the meetings and walk over surveys described in Sections 6.7.2 and 6.7.3. This work has enabled RPS to better understand the actual risk posed by the residual flooding. This has provided sufficient information to enable an outline design of the secondary measures to be undertaken with reasonable confidence on their need, buildability, cost and associated monetary benefit. Appendix H includes a drawing indicating the proposed secondary measures to manage the residual flood risk within the urban area.

The key objective of the secondary measures was to convey, divert and store the predicted flow paths away from properties. Where possible this was achieved by utilising the road networks and spare capacity within the existing drainage infrastructure to convey water but inevitably required the creation of new storage areas and upgrades to the piped network. Donegal County Council was particularly concerned with the capacity available in some of the culverted sections of the main watercourse as it flows through the Diamond area of the town. It was therefore imperative that no additional flows were added at this location and if possible the volumes of overland run-off reaching the watercourse should be reduced.

RPS have proposed a wide range of secondary measures of varying size and scale across the town but the main alteration was the creation of drainage conduits to convey the stormwater through the town. This was achieved by essentially altering the urban drainage areas or sub-catchments within the town and creating three new main drainage pipes or culverts which would collect, convey and discharge the excess stormwater to the watercourses to the South and East of the town. Figure 6.10 highlights these three main arterial drainage routes and a description of each is provided below.

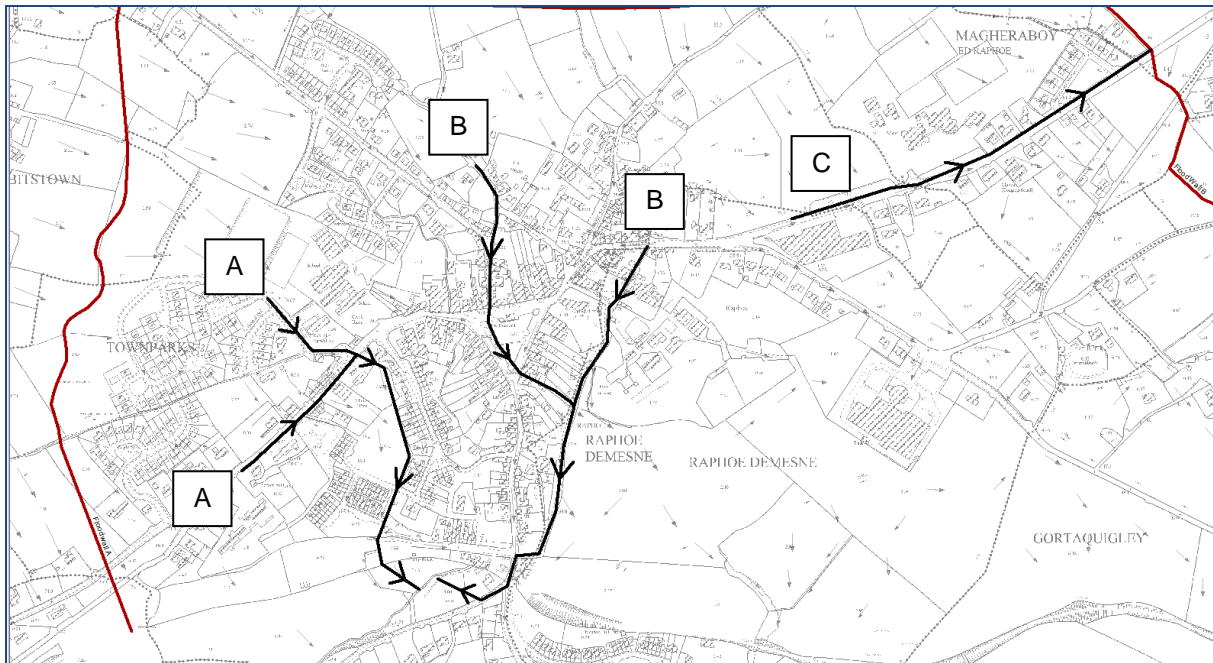


Figure 6.10 - Proposed Main Drainage Conduits – Arterial Routes A, B, C

Arterial Route A – Additional gullies along Meeting House Street and raising of kerbs will assist in collecting excess stormwater along this road and will be discharged into a new manhole at the junction with Cathedral Hill. Also discharging into the manhole will be the collected run-off from Deelee College. This run-off from the College grounds previously flowed out of the gates and straight down St Eunan's Terrace where it contributed to the flooding in the vicinity of the main watercourse near the junction with Guesthouse End. By collecting this flow, and the flow from Meeting House Street, and upgrading to a 600mm pipe this water is now conveyed along Route A, parallel to St Eunan's Terrace and directly to the main watercourse at the shown location south of the town. An existing unused 600mm pipe found along much of this route was calculated to be undersized and requires upgrading to a 1050mm pipe. By providing this new arterial drainage route it addresses the majority of the issues to the west of the town (in combination with the other proposed secondary measures) and also serves to reduce the flows to the main watercourse as it passes through the Diamond and particularly the lower end of the town.

Arterial Route B – Collects the residual flood flows from Irish Row and that which collects at the top of the Diamond and conveys these down the western and southern sides of the Diamond in a new 1050mm pipe. This upgraded pipe will continue along its current route between the Danske Bank and McCarron's Butchers and discharge to a new arterial 1500mm culvert which will be laid to the east of Castle Road. This will help reduce the risk to the Diamond and divert further flows away from the main watercourse at this location. Another upgraded 1050mm diameter culvert will also be laid from William Street, parallel to Castle Road, to meet the pipe from the Diamond and convey storm water to the main watercourse to the south of the town via Guesthouse End and Carnowen Road in a 1500mm diameter pipe. This pipe also ensures a reduction in flows along McBride street and William Street and hence the Diamond and the main watercourse.

Arterial Route C – A new upgraded 1800mm pipe will be laid along the Derry Road to collect flows emanating from Raphoe Royal School, its playing fields and the surrounding fields. This will collect flows from direct surface water run-off via a series of gullies and drainage outlets along this road and discharge them into the watercourse to the east of the town. There are also a number of storm water pipes of varying diameter between 250mm and 600mm which currently converge adjacent to the layby beside Raphoe Royal School which should be connected into the proposed 1800mm pipe. This will reduce the flood risk to those properties immediately to the south of the Derry Road when implemented in combination with the other secondary measures proposed at this location. It should be noted that the catchments of the pipes converging at the location is unknown and 1800mm has been taken as a reasonable estimation of the size of pipe that maybe required.

6.7.5 Cost Benefit Analysis

RPS updated the cost benefit analysis for the scheme on the basis of the additional analysis described in Section 6.7. This has included a full costing of all secondary measures as presented in Table 6.18 (a further more detailed breakdown is provided in Appendix I).

Table 6.18 - Final Proposed Secondary Measure Costing

	Whole Life Cost
Walls and Embankments	€ 1,417,500
Drainage Infrastructure	€ 4,223,200
Road Re-profiling and Landscaping	€ 111,500
Additional Works	€ 732,000
Total	€ 6,484,200

In order to assess the reduction in damage it would be normal practice to modify the hydraulic model and produce defended model runs identical to the process undertaken for the primary options for this project. The defended flood extents can then be used to determine the reduction in flood risk and associated economic benefit. However, for the reasons stated in Section 6.6.1 of this report, additional modelling has not been undertaken for the secondary measures in Raphoe. Instead an assumption has been made that the proposed measures will remove all flood damages up to the 1% AEP event. The results of this analysis are presented in Table 6.19.

Table 6.19 - Economic Damage figures

	Total AAD	Total pvD	Benefit
Current	€ 8,481,432	€22,453,691	-
Primary	€ 6,529,504	€ 10,180,080	€ 12,273,611
Primary and Secondary	€ 181,641	€ 2,432,565	€ 20,021,126

Therefore the additional benefit to properties within the confines of the primary option provided by the proposed final secondary measures equates to € 7,747,515. This translates to a cost benefit ratio of 1.19 for the proposed secondary measures in dealing with the residual risk. These figures are presented in Table 6.20.

Table 6.20 - Cost Benefit Analysis of Secondary Measures

Residual pvD with Primary Option in Place	Residual pvD with Primary and Secondary Options in Place	Benefit	Total Cost of Secondary Options	BCR
€ 10,180,080	€ 2,432,565	€ 7,747,515	€ 6,484,200	1.19

Table 6.21 considers the overall cost benefit analysis for both the primary and secondary measures combined giving an overall cost benefit ratio of 2.71.

Table 6.21 - Summary of Cost Benefit Analysis

	Total pvD	Benefit	Associated Construction Costs	Overall BCR
Current	€22,453,691	-	-	
Primary	€ 10,180,080	€ 12,273,611	€895,297	13.71
Primary and Secondary	€ 2,432,565	€ 20,021,126	€ 7,379,497	2.71

6.7.6 Assumptions

The analysis undertaken by RPS and described in Section 6.7 of this report is adequate to provide sufficient certainty in the assessment of the cost benefit for both the proposed primary and secondary measures. With any scheme at this stage of development there are assumptions related to ground conditions, land owner negotiations etc. However it is important to recognise that there are a number of specific assumptions to Raphoe which RPS would recommend are considered further during the detailed design process.

- The drainage network in Raphoe is not surveyed in detail. The information provided to RPS has been based on the extensive, local knowledge of Donegal County Council Engineers. The network would need to be fully surveyed to ensure all proposed pipe sizes and the assumed drainage areas within the town are correct. If required the InfoWorks ICM model could then integrate the drainage network to fully establish the impact of the proposed secondary measures.
- A full set of existing service enquiries needs to be undertaken to establish any conflict with the proposed new culverts and drainage upgrades.
- The condition of the main culvert through the town is unknown and only its current geometry has been included within the model. RPS would recommend that a full CCTV/structural survey (where possible) is undertaken to ensure this culvert performs as assumed in the model.

6.7.7 Responsibility for the Implementation of Measures

A range of flooding sources has been identified in Raphoe along with a variety of measures to alleviate flooding from these sources. It will be necessary for these measures to be allocated to the most appropriate body for implementation. The works allocated to the OPW are predominantly outside the urban area, that is, the primary diversion measures and flood storage areas and also works in the vicinity of the river which runs through the town. The DCC works are related to the improvement of the urban drainage network within the town incorporating laying new pipes and improving how overland flow enters the network. The flood risk measures have been categorised into groups in Table 6.22 below along with the body most likely to have ownership of each. A colour-coded drawing has been included in Appendix J which shows the location of the measures and which body would likely be responsible for progressing them. A description of each measure is included within Appendix I, which relates to the measure ID found on the "Responsibility of Secondary Measures" drawing in Appendix J.

Table 6.22 – Allocation of Works Relating to The Type of Measure

Type of Measure	Responsible Body
Primary Diversion Measure	OPW
Storage Measures	OPW
Works in the Vicinity of the Watercourse	OPW
Improvements to Road and Urban Water Drainage Network	Donegal County Council

7 CONSULTATION AND UPDATING PREFERRED FRM OPTIONS

Consultation on the preferred flood risk management options for Raphoe was undertaken as part of the overall consultation process for the North West – Neagh Bann (NWNB) Flood Risk Management Plans (Unit of Management 01). Public Consultation Days (PCDs) were held throughout County Donegal as shown in Table 7.1.

Table 7.1- Record of County Donegal Public Consultation Days

Date	Location	Attendees	
		Elected Members	Public
13.10.16	Lifford	1	16
18.10.16	Letterkenny	2	14
18.10.16	Carndonagh	2	9
19.10.16	Dungloe	0	7
19.10.16	Donegal Town	0	25

For each PCD Elected Members were briefed at 1pm and public consultation using a drop in format with small group discussions began at 2pm. Members of the project team (OPW, Donegal County Council and RPS) were in attendance to discuss drawings showing preferred options, answer questions and record comments or submissions made by PCD attendees. A PCD feedback register was prepared during each event and a summary report of submissions received prepared thereafter.

There were no comments or submissions made with respect to the Raphoe flood risk management options at any of the PCDs. Therefore no further update was made to the preferred flood risk management options.

8 SUMMARY OF PREFERRED FRM OPTIONS

The primary objective of this report is to develop preferred flood risk management options to manage present and future flood risk to the Study Area. The optioneering process involved data collection to inform flood risk assessment which quantified and mapped the adverse consequences of flooding socially, environmentally, culturally and economically. This is summarised in Table 3.2.

Monetary damage to certain receptors was completed to inform the economic assessment and provide the amount of potential benefit that would occur if a FRM measure is implemented to prevent said damage. The total Annual Average Damage (AAD) for Raphoe is €8,481,432. The total Present Value Damage (pvD) is €22,453,691. Acknowledgement was made of the limitations of the flood damage assessment and sensitivity analysis undertaken as discussed in Chapter 6.5.

A long list of viable structural and non structural options and measures for effective and sustainable management of flood risk within the Study Area was compiled. The preferred design standard for this study is the 1% AEP event for pluvial flood risk. The long list of measures was screened based on technical merit drawing on engineering judgement, information from local engineers, comments made at draft mapping public consultation day, and reviewing animations of model output. Careful consideration was given to the flood mechanisms in Raphoe to ensure all measures considered the correct source of flooding and the correct flow path. Measures which have technical merit were divided into primary and secondary categories. Primary measures are those which will be considered as having a reasonable likelihood of providing the required standard of protection, or at least reducing the flood risk, to the majority of properties at risk from a 1% AEP event. Secondary measures were designed to address localised flooding issues to a small number of properties at risk during the 1% AEP event.

Three potential flood risk management options consisting of primary measures were found to be technically, socially and environmentally feasible (see Table 6.5 and Appendix B). Further analysis of Benefit Cost Ratio (BCR), the Multi Criteria Analysis Score and Net Benefit ruled Options 2 and 3 out since there are not economically viable and are more environmentally damaging from a visual and aesthetic perspective. Therefore Option 1 is considered the preferred primary option with a BCR of 13.71:

- Diversion of surface water flow originating from the hills to the north and west of Raphoe by the creation of an open channel to collect and divert flows away from the town. Earth embankments from the excavated channel will be created on the lower side of the channels to provide freeboard and prevent overtopping. Diverted flow will be directed to existing river channels to the south-west and south-east of the town respectively (refer to Section 6.4 and Appendix B).

A range of sensitivity testing was undertaken to ensure robustness of preferred option selection (Chapter 6.5) and that the preferred option remains cost beneficial despite any uncertainty. The testing resulted in reduction of BCR to 8.99 which remains positive and therefore viable in terms of cost – benefit.

However it has been acknowledged that with any of the three primary options considered residual damage of €10,180,080 still occurs within Raphoe town itself. This occurs because although the FRM options divert the majority of the flow away from the town, rain is still falling directly onto the urban area (effectively behind the defences) in sufficient quantities to continue to cause damage to properties. To address this, further analysis and consideration of secondary measures was undertaken (Section 6.6). This included walkover survey and meetings with DCC engineers, additional hydrology and hydraulic modelling, outline design of secondary measures and cost benefit assessment. The key objective of the secondary measures is to convey, divert and store the predicted flow paths away from properties within the limited space available within the urban area.

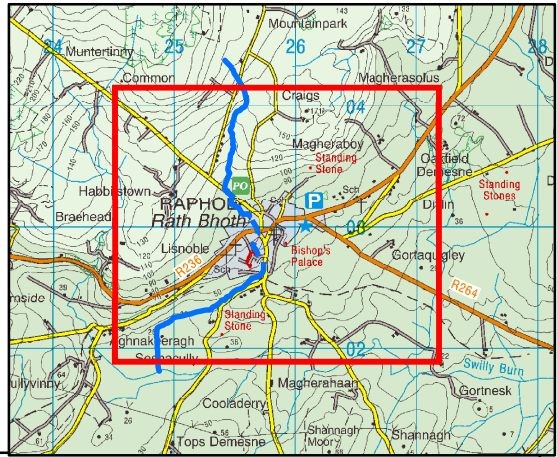
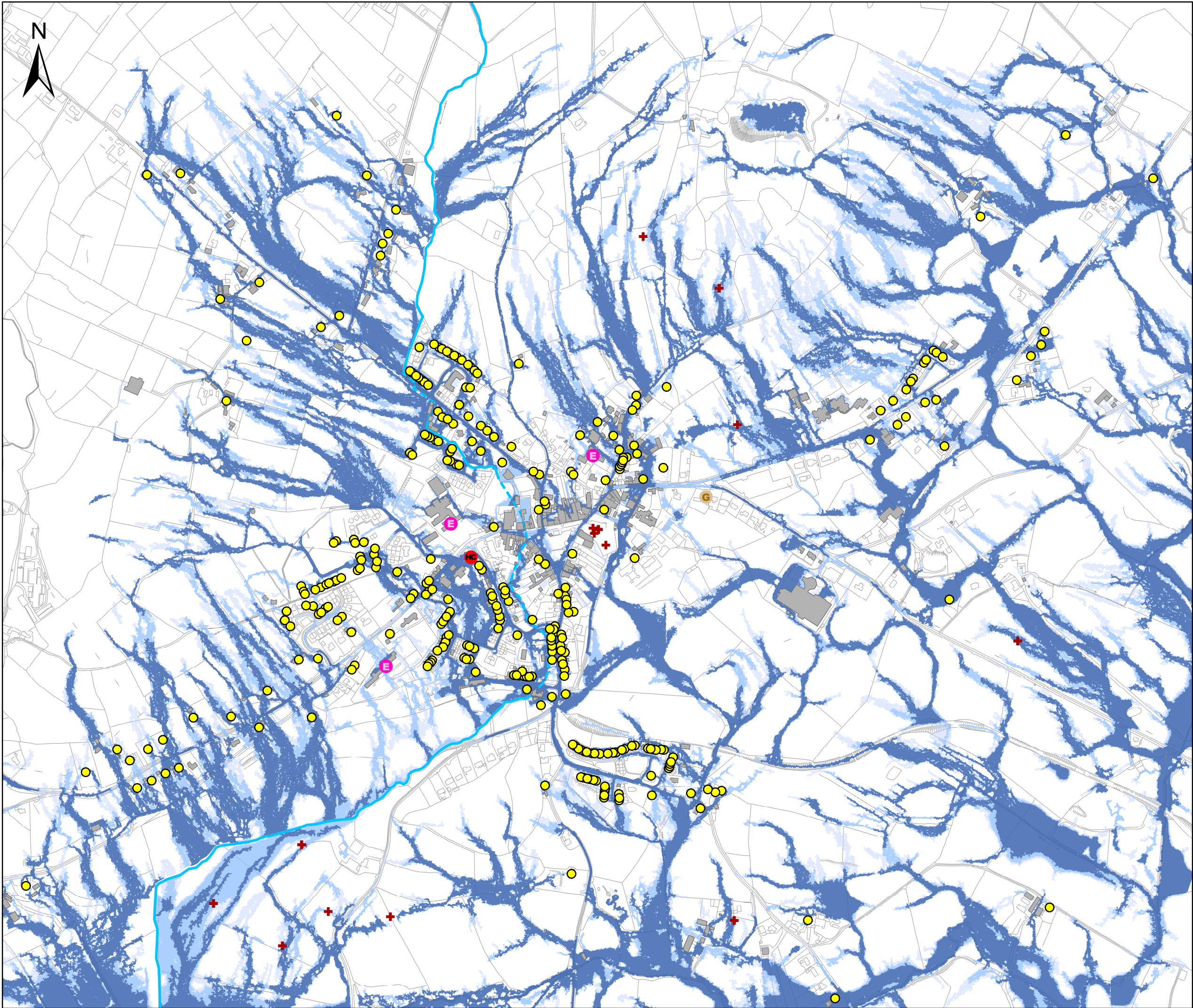
RPS have proposed a wide range of secondary measures of varying size and scale across the town (see Appendix 7) but the main alteration is the creation of drainage conduits to convey the stormwater through the town. This is achieved by altering the urban drainage areas or sub-catchments within the town and creating three new main drainage pipes or culverts which would collect, convey and discharge the excess stormwater to the watercourses to the South and East of the town (see Section 6.7.4). Cost benefit analysis of the proposed secondary measures in dealing with residual risk and in

conjunction with preferred Option 1 (primary measures) was undertaken resulting in an overall BCR of 2.71 (Table 6.21).

In terms of implementation of measures it is recommended that OPW take responsibility for the primary diversion and storage measures and works in the vicinity of the watercourse, whilst Donegal County Council take responsibility for improvements to the road and urban water drainage network.

Appendix A

Flood Risk Maps



"The viewer of this map should refer to the Disclaimer, Guidance Notes and Conditions of Use that accompany this map."

Legend

✚ Architectural Heritage

Properties

● Residential Properties

High Vulnerability Sites

ⓔ Schools

Valuable Social Infrastructure

ⓖ Garda Stations

ⓗ Health Centres

■ Building Outlines

Watercourse

— Open channel watercourse

- - - Culverted watercourse

Flood Extents

■ 10% AEP Event

■ 1% AEP Event

■ 0.1% AEP Event



FINAL

TITLE

RAPHOE
General Risk - Social and Cultural Heritage

CLIENT



PROJECT

RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY

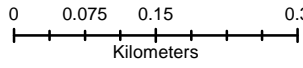


Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

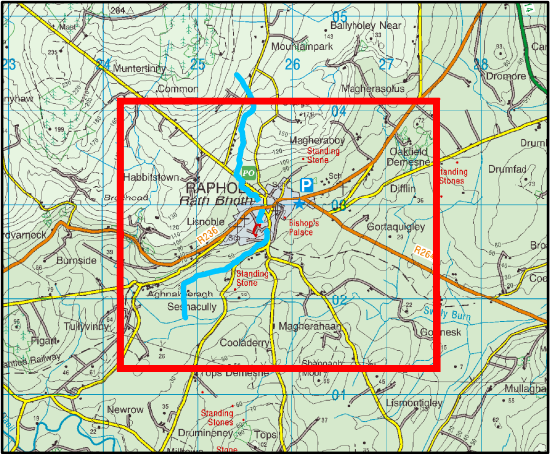
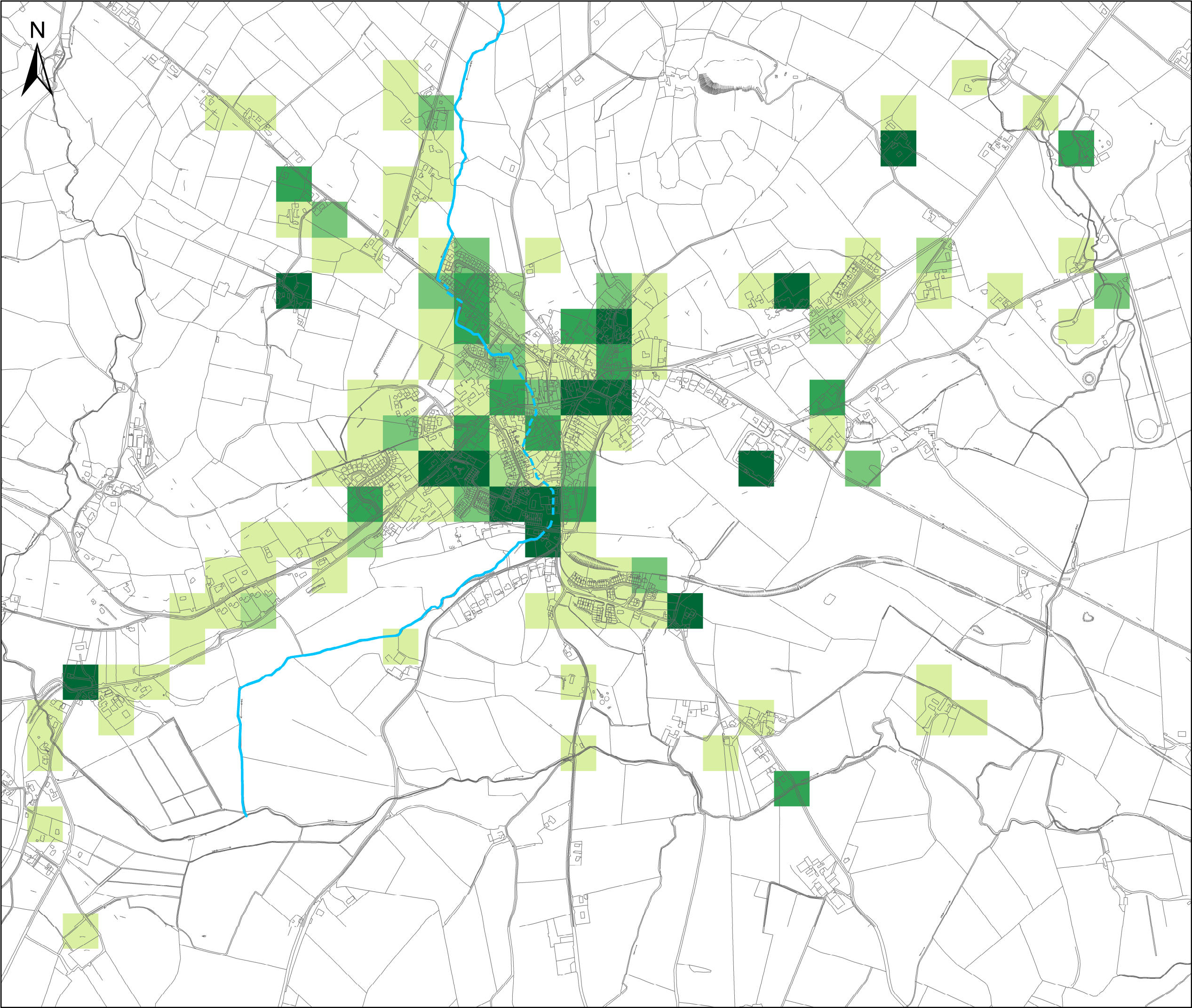
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Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 19/09/2014



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Legend

Watercourse

— Open channel watercourse

- - - Culverted watercourse

Density of Economic Risk (€k / Ha)

- 1 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- >100



FINAL

TITLE

RAPHOE
Economic Risk

CLIENT



PROJECT

RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY



Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

Drawing No. :

IBE0809_RAPHOE_ECONOMICRISK

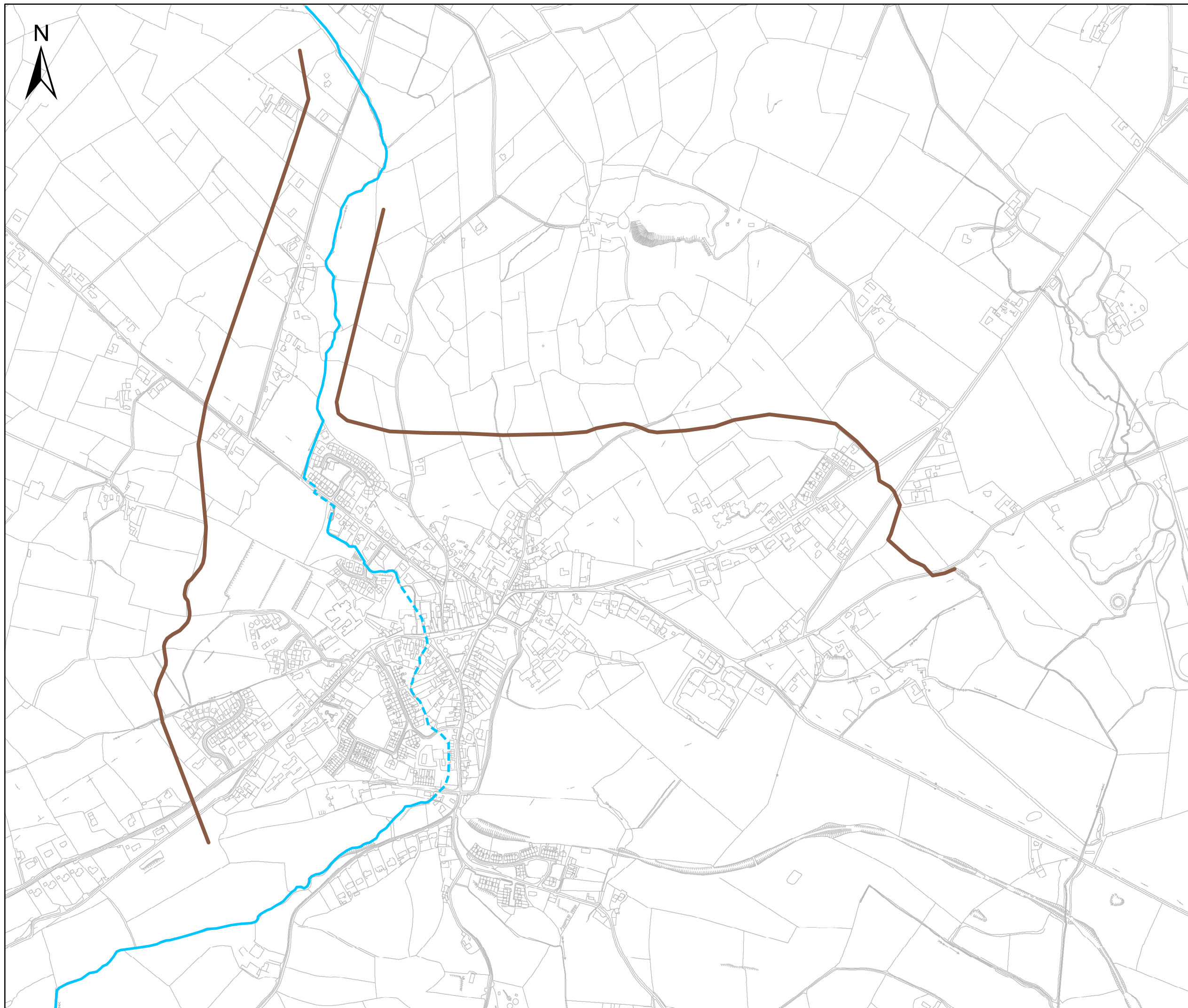
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Kilometers

SCALE AT A3:1:10,000

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Checked By : AJ
Approved By : AJ
Date : 19/09/2014

Appendix B

Potential FRM Options



"The viewer of this map should refer to the Disclaimer, Guidance Notes and Conditions of Use that accompany this map."

Legend

Option 1

- Channel Diversion and Embankment

Watercourse

- Open channel watercourse
- - - Culverted watercourse



FINAL

TITLE

FRM Option 1

CLIENT

PROJECT



RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY



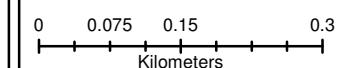
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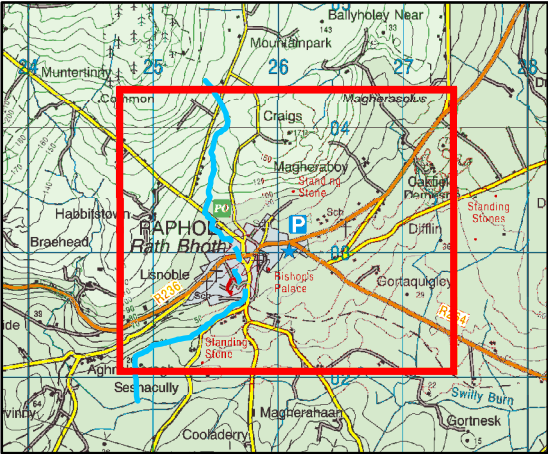
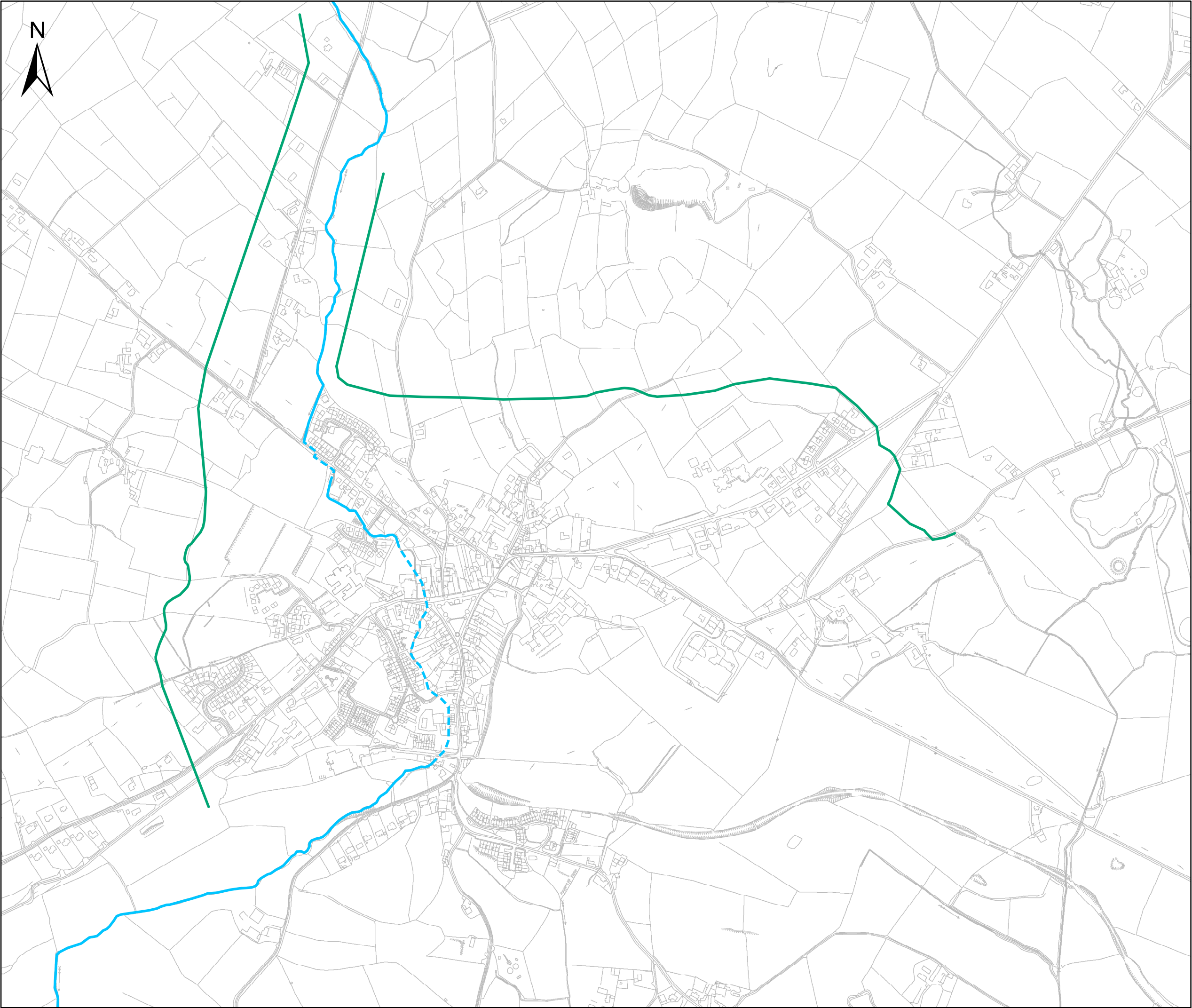
Drawing No. :

IBE0809_RAPHOE_OPT1

Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 23/06/2014



SCALE AT A3:1:8,000



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Legend

Option 2

— Channel Diversion and Retaining Wall

Watercourse

— Open channel watercourse

- - - Culverted watercourse



FINAL

TITLE

FRM Option 2

CLIENT



PROJECT

RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY



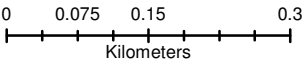
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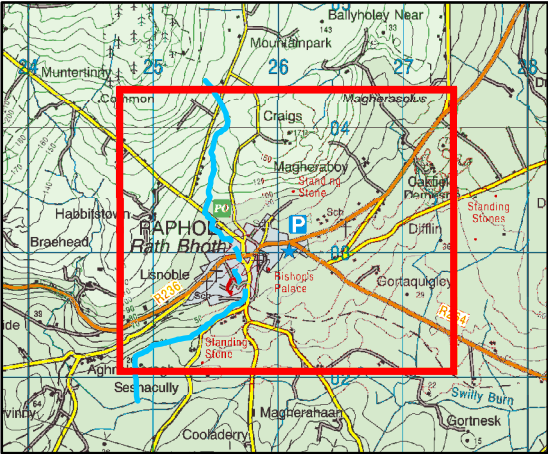
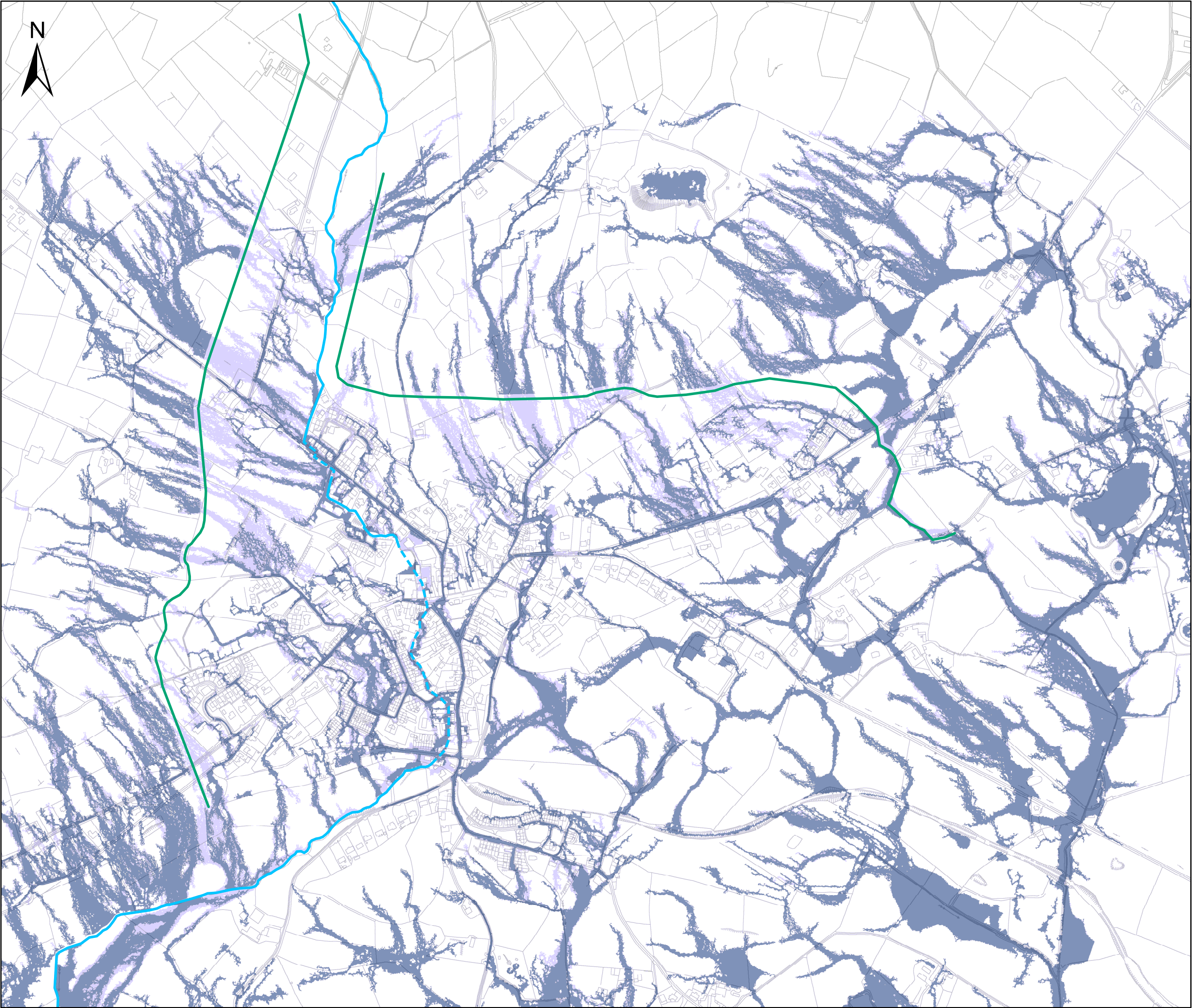
Drawing No.:

IBE0809_RAPHOE_OPT2

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Approved By : AJ
Date : 23/06/2014



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- Legend**
- Option 2**
- Channel Diversion and Retaining Wall
- Watercourse**
- Open channel watercourse
 - Culverted watercourse
- Option 2 - Flood Extents**
- 1% AEP Event
- Existing Conditions - Flood Extents**
- 1% AEP Event



TITLE

FRM Option 2 with Flood Extents

CLIENT PROJECT

OPW RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

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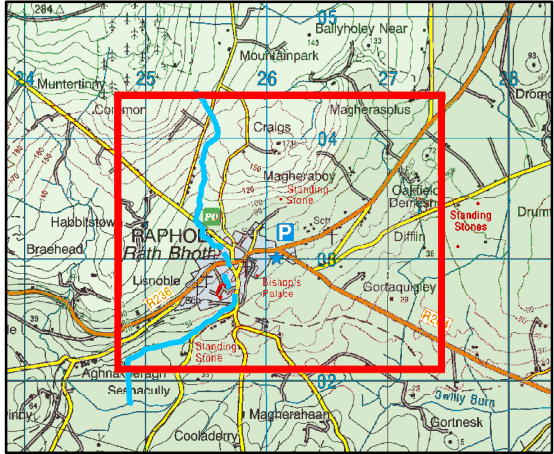
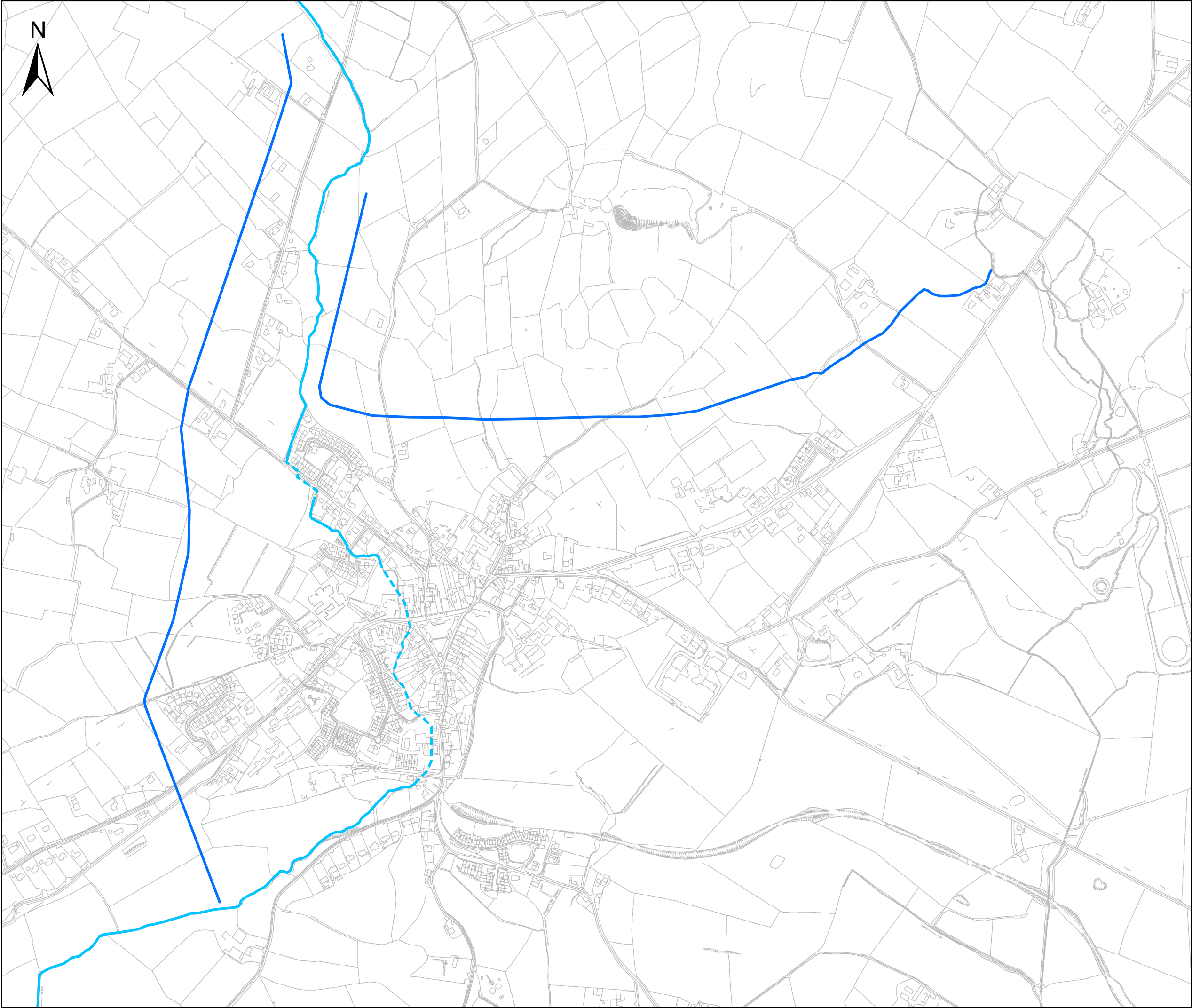
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Drawing No. : IBE0809_RAPHOE_OPT2&EXTENTS

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Date : 23/06/2014



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Legend

Option 3

— Retaining Wall

Watercourse

— Open channel watercourse

- - - Culverted watercourse



FINAL

TITLE

FRM Option 3

CLIENT



PROJECT

RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY



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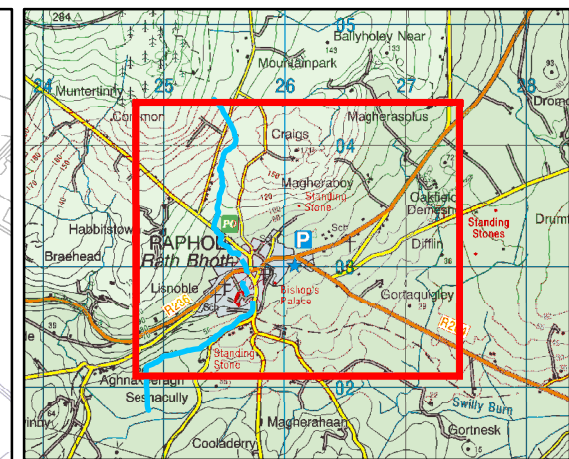
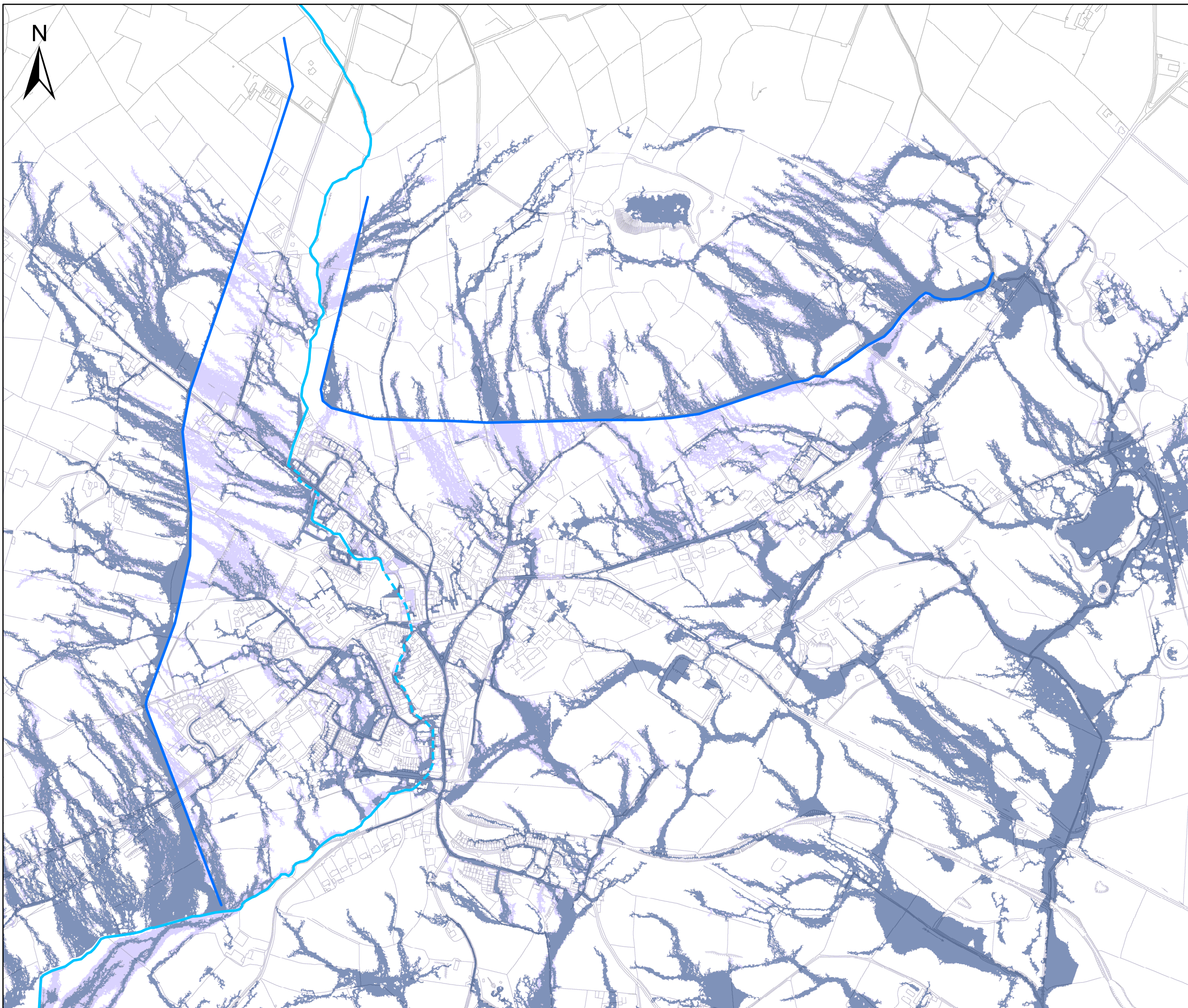
Drawing No. :

IBE0809_RAPHOE_OPT3

0 0.075 0.15 0.3
Kilometers

SCALE AT A3:1:8,000

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Legend

Option 3

- Retaining Wall

Watercourse

-  Open channel watercourse
 Culverted watercourse

Option 3 - Flood Extents

- 1% AEP Extent

Existing Conditions - Flood Extents

- 1% AEP Event



FINAL

TITLE

FRM Option 3 with Flood Extents

CLIENT



PROJECT

RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

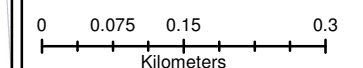


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Drawing No. :

IBE0809_RAPHOE_OPT3&EXTENTS



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Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 23/06/2014

Appendix C

Costing of FRM Options

Embankment 1 - North

Scaling factor

1.344572715

Elevations from LIDAR in ArcMap

Embankment 1		Perpendicular to flow		Fall	Average	Along flow direction		Fall	Avg. Slope (S)
Segment	Cross-section	Upper	Lower			Upper	Lower		
CS1	A1	131.8	122.9	8.9	7.2	132.4	121.3	11.1	0.06
	B1	117.3	111.8	5.5		121.7	108.8	12.9	
CS2	C1	110.7	101.2	9.5	11.45	107.4	102.8	4.6	0.03525
	D1	102.8	89.4	13.4		101.1	91.6	9.5	
CS3	E1	96.9	84.2	12.7	12.53	91.7	85.9	5.8	0.0395
	F1	95.3	81.3	14		88.3	78.2	10.1	
	G1	86.1	75.2	10.9		83.3	75.5	7.8	
CS4	G1	86.1	75.2	10.9	5.53	83.3	75.5	7.8	0.025
	H1	77.7	73.2	4.5		78	70.8	7.2	
	I1	67.1	65.9	1.2		74.6	74.6	0	
CS5	J1	60.7	61.5	-0.8	3.05	61.5	57.9	3.6	0.05
	K1	56.5	49.6	6.9		55.5	39.1	16.4	

Total Volumes for Embankment Excavations and Fill Material

Section	Area Excavated (m²)	Area to fill (m²)	Extra material needed (m³)	Length of section (m)	Volume to be excavated (m³)	Volume of extra material needed (m³)	Sloped surfaces after excavation, cross section (m)	Flat surfaces after excavation, cross section (m)	New sloped surfaces area (m²)	New flat surfaces area (m²)
CS1	2.2803	2.7185	0.4382	464.98	1060.30	203.76	10.3581	1.5	4816.33	697.47
CS2	3.095	4.2065	1.1115	574.54	1778.22	638.61	13.3512	1.5	7670.86	861.82
CS3	2.5408	4.4275	1.8867	294.91	749.32	556.41	13.113	1.5	3867.21	442.37
CS4	2.7993	2.1584	-0.6409	404.14	1131.30	-259.01	10.1717	1.5	4110.75	606.20
CS5	1.68	1.5302	-0.1498	380.95	640.00	-57.07	8.513	1.5	3243.07	571.43

Totals

2119.53 5359.13 1082.70

23708.22 3179.30

Cost of Provisions

SPON page no.	Job	Description	Rate/m	Rate/m²	Rate/M³	Rate/unit	Total Cost	
170	Excavation of embankment	Excavation for cuttings 0.5 - 1m	€ -	€ -	€ 2.60	€ -	€ 18,734.94	100% material other than topsoil, rock and other artificial hard material
393	Creating	Deposition of fill in embankments	€ -	€ -	€ 0.84	€ -	€ 6,052.83	
394	Additional fill	Imported graded granular fill - crushed gravels, suitable for embankments	€ -	€ -	€ 21.73	€ -	€ 31,633.81	
396	Compaction of fill	Compaction of granular fill material in embankments	€ -	€ -	€ 0.33	€ -	€ 480.40	
476	Grass seeding	Grass seeding < 10% gradient	€ -	€ 0.65	€ -	€ -	€ 2,778.62	
476	Grass seeding	Grass seeding > 10% gradient	€ -	€ 0.78	€ -	€ -	€ 24,864.39	
479	Grass cutting	Medium frequency on central reserves	€ -	€ 0.06	€ -	€ -	€ 2,190.82	
478	Planting hedgerow	Hedge plants - Double row at 200mm centres	€ 23.87	€ -	€ -	€ -	€ 68,026.27	
479	Maintaining hedgerow	Trim field hedge to specified height and shape using cutting bar	€ 1.79	€ -	€ -	€ -	€ 15,303.77	3 times a year
329	Fence (up-slope, along hedgerow)	Timber post and wire, 1.2m high, driven	€ 8.93	€ -	€ -	€ -	€ 25,449.29	
330	Field gates - metal	Metal gates, tubular steel 3m x 1.175m	€ -	€ -	€ -	€ 82.67	€ 3,112.36	2 per field x 14 fields

Summary

	Total cost	Maintenance	Construction cost, materials
100% Topsoil	€ 198,627.52	€ 17,494.60	€ 181,132.92

Embankment 2 - West

Elevations from LIDAR in ArcMap

Embankment 2		Perpendicular to flow		Fall	Average	Along flow direction		Fall	Avg. Slope (S)
Segment	Cross-section	Upper	Lower			Upper	Lower		
CS6	A2	182.2	171.2	11	10.85	180.5	172.5	8	0.0725
	B2	172.0	161.3	10.7		170.5	164	6.5	
CS7	B2	172.0	161.3	10.7	11.17	170.5	164	6.5	0.05
	C2	146.9	134.6	12.3		143.6	138.3	5.3	
	D2	128.6	118.1	10.5		124.4	121.7	2.7	
CS8	D2	128.6	118.1	10.5	9.8	124.4	121.7	2.7	0.033
	E2	117.0	108.3	8.7		115.5	109.9	5.6	
	F2	110.6	100.4	10.2		107.9	106.3	1.6	
CS9	F2	110.6	100.4	10.2	8.17	107.9	106.3	1.6	0.006
	G2	108.4	101.2	7.2		104.8	105.4	-0.6	
	H2	108.9	101.8	7.1		104.9	104.1	0.8	
CS10	H2	108.9	101.8	7.1	2.4	104.9	104.1	0.8	0.085
	I2	92.2	88.3	3.9		94.5	84.8	9.7	
	J2	55.1	58.9	-3.8		64.6	49.6	15	

Total Volumes for Embankment Excavations and Fill Material

Section	Area Excavated (m^2)	Area to fill (m^2)	Extra material needed (m^2)	Length of section (m)	Volume to be excavated (m^3)	Volume of extra material needed (m^3)	Sloped surfaces after excavation, cross section (m)	n, cross section (m)	New sloped surfaces area (m^2)	New flat surfaces area (m^2)
CS6	1.889	3.4892	1.6002	110.85	209.39	177.38	11.0773	1.5	1227.88	166.27
CS7	2.455	3.8428	1.3878	723.88	1777.12	1004.60	12.356	1.5	8944.22	1085.82
CS8	2.9852	3.5244	0.5392	345.69	1031.97	186.40	12.1007	1.5	4183.14	518.54
CS9	2.3165	2.7918	0.4753	286.52	663.73	136.19	10.0937	1.5	2892.09	429.79
CS10	1.6892	2.0676	0.3784	424.81	717.59	160.75	10.1193	1.5	4298.81	637.22
Totals				1891.75	4399.80	1665.31	21546.14			
							2837.63			

Cost of Provisions

SPON page no.	Job	Description	Rate/m	Rate/m^2	Rate/M^3	Rate/unit	Total Cost
170	Excavation of embankment	Excavation for cuttings 0.5 - 1m	€ -	€ -	€ 2.60	€ -	€ 15,381.21
393	Creating	Deposition of fill in embankments	€ -	€ -	€ 0.84	€ -	€ 4,969.32
394	Additional fill	Imported graded granular fill - crushed gravels, suitable for embankments	€ -	€ -	€ 21.73	€ -	€ 48,656.17
396	Comapction of fill	Compaction of granular fill material in embankments	€ -	€ -	€ 0.33	€ -	€ 738.91
476	Grass seeding	Grass seeding < 10% gradient	€ -	€ 0.65	€ -	€ -	€ 2,480.01
476	Grass seeding	Grass seeding > 10% gradient	€ -	€ 0.78	€ -	€ -	€ 22,596.88
479	Grass cutting	Medium frequency on central reserves	€ -	€ 0.06	€ -	€ -	€ 1,986.82
478	Plenting hedgerow	Hedge plants - Double row at 200mm centres	€ 23.87	€ -	€ -	€ -	€ 60,715.78
479	Maintaining hedgerow	Trim field hedge to specified height and shape using cutting bar	€ 1.79	€ -	€ -	€ -	€ 13,659.14
329	Fence	Timber post and wire, 1.2m high, driven	€ 8.93	€ -	€ -	€ -	€ 22,714.37
330	Field gates - metal	Metal gates, tubular steel 3m x 1.175m	€ -	€ -	€ -	€ 82.67	€ 3,112.36

Flat surfaces after excavation

100% material other than topsoil, rock and other artificial hard material

3 times a year

2 per field x 14 fields

Summary

Material Excavated	Construction cost, materials	Maintenance	Construction cost, materials
100% Topsoil	€ 197,010.98	€ 15,645.96	€ 181,365.02

Total Costs (100% topsoil)	
Construction cost	€362,497.94
Provision for unmeasured items (20%)	€72,499.59
Provision for optimism bias (60%)	€217,498.76
Maintenance costs (NPV over 50yrs)	€77,864.56
Detailed design (design fees) (6%)	€21,749.88
Construction supervision (5%)	€18,124.90
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€76,124.57
Cost of land acquisition/compensation (12.5%)	€45,312.24
allowance for art (1%)	€3,624.98
Project Whole Life Cost	€895,297.41

Summary	
Total Damage	€28,862,553.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	2.35
Total Construction Cost	€362,497.94
Project Whole Life Cost	€895,297.41
BCR	13.71
MCA	1220
MCA BCR	1362.7

Retaining wall 1 - North	
Total Length (m)	2119.53
Total height (m)	1.2 - 2m
	Estimated rate € /m
Reinforced concrete wall and foundations with piling	3000
Cost	€6,358,595.70

Retaining wall 2 - West	
Total Length (m)	1891.75
Total height (m)	1.2 - 2m
	Estimated rate € /m
Reinforced concrete wall and foundations with piling	3000
Cost	€5,675,264.70

Total cost	€12,033,860.40
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Total Costs (100% topsoil)

Construction cost	€12,033,860.40
Provision for unmeasured items (20%)	€2,406,772.08
Provision for optimism bias (60%)	€7,220,316.24
Maintenance costs (NPV over 50yrs)	€2,584,873.21
Detailed design (design fees) (6%)	€722,031.62
Construction supervision (5%)	€601,693.02
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€2,527,110.68
Cost of land acquisition/compensation (12.5%)	€1,504,232.55
allowance for art (1%)	€120,338.60
Project Whole Life Cost	€29,721,228.42

Summary

Total Damage	€28,862,553.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	2.35
Total Construction Cost	€12,033,860.40
Project Whole Life Cost	€29,721,228.42
BCR	0.41
MCA	1015
MCA BCR	34.2

Retaining wall 1 - North	
Total Length (m)	2040.32
Max. Water Depth at Wall (m)	2.19
Min. Water Depth at Wall (m)	0.01
Freeboard (m)	0.50
Total height (m)	2.69
	Estimated rate € /m
Reinforced concrete wall and foundations with piling	4000
Cost	€8,161,299.74

Retaining wall 2 - West	
Total Length (m)	2103.95
Max. Water Depth at Wall (m)	4.63
Min. Water Depth at Wall (m)	0.01
Freeboard (m)	0.50
Total height (m)	5.13
	Estimated rate € /m
Reinforced concrete wall and foundations with piling	8000
Cost	€16,831,582.42

Total cost	€24,992,882.15
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Total Costs (100% topsoil)

Construction cost	€24,992,882.15
Provision for unmeasured items (20%)	€4,998,576.43
Provision for optimism bias (60%)	€14,995,729.29
Maintenance costs (NPV over 50yrs)	€5,368,471.09
Detailed design (design fees) (6%)	€1,499,572.93
Construction supervision (5%)	€1,249,644.11
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€5,248,505.25
Cost of land acquisition/compensation (12.5%)	€3,124,110.27
allowance for art (1%)	€249,928.82
Project Whole Life Cost	€61,727,420.34

Summary

Total Damage	€28,862,553.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	2.35
Total Construction Cost	€24,992,882.15
Project Whole Life Cost	€61,727,420.34
 BCR	 0.20
MCA	560
MCA BCR	9.1

Embankment 1

Scaling factor

1.344572715

Elevations from LIDAR in ArcMap

Embankment 1		Perpendicular to flow		Fall	Average	Along flow direction		Fall	Avg. Slope (S)
Segment	Cross-section	Upper	Lower			Upper	Lower		
CS1	A1	131.8	122.9	8.9	7.2	132.4	121.3	11.1	0.06
	B1	117.3	111.8	5.5		121.7	108.8	12.9	
CS2	C1	110.7	101.2	9.5	11.45	107.4	102.8	4.6	0.03525
	D1	102.8	89.4	13.4		101.1	91.6	9.5	
CS3	E1	96.9	84.2	12.7	12.53	91.7	85.9	5.8	0.0395
	F1	95.3	81.3	14		88.3	78.2	10.1	
	G1	86.1	75.2	10.9		83.3	75.5	7.8	
CS4	G1	86.1	75.2	10.9	5.53	83.3	75.5	7.8	0.025
	H1	77.7	73.2	4.5		78	70.8	7.2	
	I1	67.1	65.9	1.2		74.6	74.6	0	
CS5	J1	60.7	61.5	-0.8	3.05	61.5	57.9	3.6	0.05
	K1	56.5	49.6	6.9		55.5	39.1	16.4	

Total Volumes for Embankment Excavations and Fill Material

Section	Area Excavated (m^2)	Area to fill (m^2)	Extra material needed (m^2)	Length of section (m)	Volume to be excavated (m^3)	Volume of extra material needed (m^3)	Sloped surfaces after excavation, cross section (m)	Flat surfaces after excavation, cross section (m)	New sloped surfaces area (m^2)	New flat surfaces area (m^2)
CS1	2.2803	2.7185	0.4382	464.98	1060.30	203.76	10.3581	1.5	4816.33	697.47
CS2	3.095	4.2065	1.1115	574.54	1778.22	638.61	13.3512	1.5	7670.86	861.82
CS3	2.5408	4.4275	1.8867	294.91	749.32	556.41	13.113	1.5	3867.21	442.37
CS4	2.7993	2.1584	-0.6409	404.14	1131.30	-259.01	10.1717	1.5	4110.75	606.20
CS5	1.68	1.5302	-0.1498	380.95	640.00	-57.07	8.513	1.5	3243.07	571.43
Totals					2119.53	5359.13	1082.70		23708.22	3179.30

Cost of Provisions

SPON page no.	Job	Description	Rate/m	Rate/m^2	Rate/M^3	Rate/unit	Total Cost	
170	Excavation of embankment	Excavation for cuttings 0.5 - 1m	£	-	£	2.60	£	100% material other than topsoil, rock and other artificial hard material
170	Rock excavation (10%)	If rock excavation occurs (10%)	£	-	£	37.92	£	10% rock, 90% material other than topsoil, rock and other artificial hard material
170	Rock excavation (20%)	If rock excavation occurs (20%)	£	-	£	37.92	£	20% rock, 80% material other than topsoil, rock and other artificial hard material
170	Rock excavation (50%)	If rock excavation occurs (50%)	£	-	£	37.92	£	50% rock, 50% material other than topsoil, rock and other artificial hard material
393	Creating	Deposition of fill in embankments	£	-	£	0.84	£	
		Imported graded granular fill - crushed gravels, suitable for embankments	£	-	£	21.73	£	
394	Additional fill	Compaction of granular fill material in embankments	£	-	£	0.33	£	
396	Comapction of fill		£	-	£	0.65	£	
476	Grass seeding	Grass seeding < 10% gradient	£	-	£	0.78	£	
476	Grass seeding	Grass seeding > 10% gradient	£	-	£	0.06	£	
479	Grass cutting	Medium frequency on central reserves	£	-	£	-	£	
478	Planting hedgerow	Hedge plants - Double row at 200mm centres	£	23.87	£	-	£	
479	Maintaining hedgerow	Trim field hedge to specified height and shape using cutting bar	£	1.79	£	-	£	3 times a year
329	Fence (up-slope, along hedgerow)	Timber post and wire, 1.2m high, driven	£	8.93	£	-	£	
330	Field gates - metal	Metal gates, tubular steel 3m x 1.175m	£	-	£	-	£	2 per field x 14 fields

Summary

Material	Total cost	Maintenance	Construction cost, materials
0% Rock	€ 198,627.52	€ 17,494.60	€ 181,132.92
10% Rock	€ 224,078.22	€ 17,494.60	€ 206,583.62
20% Rock	€ 249,528.92	€ 17,494.60	€ 232,034.32
50% Rock	€ 325,881.01	€ 17,494.60	€ 308,386.41

Embankment 2

Scaling factor

1.344572715

Elevations from LIDAR in ArcMap

Embankment 2		Perpendicular to flow		Fall	Average	Along flow direction		Fall	Avg. Slope (S)
Segment	Cross-section	Upper	Lower			Upper	Lower		
CS6	A2	182.2	171.2	11	10.85	180.5	172.5	8	0.0725
	B2	172.0	161.3	10.7		170.5	164	6.5	
CS7	B2	172.0	161.3	10.7	11.17	170.5	164	6.5	0.05
	C2	146.9	134.6	12.3		143.6	138.3	5.3	
	D2	128.6	118.1	10.5		124.4	121.7	2.7	
CS8	D2	128.6	118.1	10.5	9.8	124.4	121.7	2.7	0.033
	E2	117.0	108.3	8.7		115.5	109.9	5.6	
	F2	110.6	100.4	10.2		107.9	106.3	1.6	
CS9	F2	110.6	100.4	10.2	8.17	107.9	106.3	1.6	0.006
	G2	108.4	101.2	7.2		104.8	105.4	-0.6	
	H2	108.9	101.8	7.1		104.9	104.1	0.8	
CS10	H2	108.9	101.8	7.1	2.4	104.9	104.1	0.8	0.085
	I2	92.2	88.3	3.9		94.5	84.8	9.7	
	J2	55.1	58.9	-3.8		64.6	49.6	15	

Total Volumes for Embankment Excavations and Fill Material

Section	Area Excavated (m^2)	Area to fill (m^2)	Extra material needed (m^2)	Length of section (m)	Volume to be excavated (m^3)	Volume of extra material needed (m^3)	Sloped surfaces after excavation, cross section (m)	Flat surfaces after excavation, n, cross section (m)	New sloped surfaces area (m^2)	New flat surfaces area (m^2)
CS6	1.889	3.4892	1.6002	110.85	209.39	177.38	11.0773	1.5	1227.88	166.27
CS7	2.455	3.8428	1.3878	723.88	1777.12	1004.60	12.356	1.5	8944.22	1085.82
CS8	2.9852	3.5244	0.5392	345.69	1031.97	186.40	12.1007	1.5	4183.14	518.54
CS9	2.3165	2.7918	0.4753	286.52	663.73	136.19	10.0937	1.5	2892.09	429.79
CS10	1.6892	2.0676	0.3784	424.81	717.59	160.75	10.1193	1.5	4298.81	637.22

Totals

1891.75

4399.80

1665.31

21546.14

2837.63

Cost of Provisions

SPON page no.			Job	Description	Rate/m	Rate/m^2	Rate/M^3	Rate/unit	Total Cost		
170	Excavation of embankment	Excavation for cuttings 0.5 - 1m	£	-	£	-	£	2.60	£	15,381.21	100% material other than topsoil, rock and other artificial hard material
170	Rock excavation (10%)	If rock excavation occurs (10%)	£	-	£	-	£	37.92	£	36,276.00	10% rock, 90% material other than topsoil, rock and other artificial hard material
170	Rock excavation (20%)	If rock excavation occurs (20%)	£	-	£	-	£	37.92	£	57,170.79	20% rock, 80% material other than topsoil, rock and other artificial hard material
170	Rock excavation (50%)	If rock excavation occurs (50%)	£	-	£	-	£	37.92	£	119,855.16	50% rock, 50% material other than topsoil, rock and other artificial hard material
393	Creating	Deposition of fill in embankments	£	-	£	-	£	0.84	£	4,969.32	
394	Additional fill	Imported graded granular fill - crushed gravels, suitable for embankments	£	-	£	-	£	21.73	£	48,656.17	
396	Compaction of fill	Compaction of granular fill material in embankments	£	-	£	-	£	0.33	£	738.91	
476	Grass seeding	Grass seeding < 10% gradient	£	-	£	0.65	£	-	£	2,480.01	
476	Grass seeding	Grass seeding > 10% gradient	£	-	£	0.78	£	-	£	22,596.88	
479	Grass cutting	Medium frequency on central reserves	£	-	£	0.06	£	-	£	1,986.82	
478	Planting hedgerow	Hedge plants - Double row at 200mm centres	£	23.87	£	-	£	-	£	60,715.78	
479	Maintaining hedgerow	Trim field hedge to specified height and shape using cutting bar	£	1.79	£	-	£	-	£	13,659.14	3 times a year
329	Fence	Timber post and wire, 1.2m high, driven	£	8.93	£	-	£	-	£	22,714.37	
330	Field gates - metal	Metal gates, tubular steel 3m x 1.175m	£	-	£	-	£	-	£	82.67	2 per field x 14 fields

Summary

Material Excavated	Construction cost, materials	Maintenance	Construction cost, materials
0% Rock	£ 197,010.98	£ 15,645.96	£ 181,365.02
10% Rock	£ 217,905.77	£ 15,645.96	£ 202,259.81
20% Rock	£ 238,800.55	£ 15,645.96	£ 223,154.59
50% Rock	£ 301,484.92	£ 15,645.96	£ 285,838.96

Total Costs (100% topsoil)

Construction cost	€362,497.94
Provision for unmeasured items (20%)	€72,499.59
Provision for optimism bias (60%)	€217,498.76
Maintenance costs (NPV over 50yrs)	€77,864.56
Detailed design (design fees) (6%)	€21,749.88
Construction supervision (5%)	€18,124.90
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€76,124.57
Cost of land acquisition/compensation (12.5%)	€45,312.24
allowance for art (1%)	€3,624.98
Project Whole Life Cost	€895,297.41

Summary

Total Damage	€22,453,691.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	1.83
Total Construction Cost	€362,497.94
Project Whole Life Cost	€895,297.41
BCR	13.71
MCA	1220
MCA BCR	1362.7

Total Costs (10% rock, 90% topsoil)

Construction cost	€408,843.43
Provision for unmeasured items (20%)	€81,768.69
Provision for optimism bias (60%)	€245,306.06
Maintenance costs (NPV over 50yrs)	€87,819.57
Detailed design (design fees) (6%)	€24,530.61
Construction supervision (5%)	€20,442.17
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€85,857.12
Cost of land acquisition/compensation (12.5%)	€51,105.43
allowance for art (1%)	€4,088.43
Project Whole Life Cost	€1,009,761.49

Summary

Total Damage	€22,453,691.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	1.83
Total Construction Cost	€408,843.43
Project Whole Life Cost	€1,009,761.49
BCR	12.15
MCA	1220
MCA BCR	1208.2

Total Costs (20% rock, 100% topsoil)

Construction cost	€455,188.91
Provision for unmeasured items (20%)	€91,037.78
Provision for optimism bias (60%)	€273,113.35
Maintenance costs (NPV over 50yrs)	€97,774.58
Detailed design (design fees) (6%)	€27,311.33
Construction supervision (5%)	€22,759.45
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€95,589.67
Cost of land acquisition/compensation (12.5%)	€56,898.61
allowance for art (1%)	€4,551.89
Project Whole Life Cost	€1,124,225.57

Summary

Total Damage	€22,453,691.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	1.83
Total Construction Cost	€455,188.91
Project Whole Life Cost	€1,124,225.57
BCR	10.92
MCA	1220
MCA BCR	1085.2

Total Costs (50% rock, 50% topsoil)

Construction cost	€594,225.37
Provision for unmeasured items (20%)	€118,845.07
Provision for optimism bias (60%)	€356,535.22
Maintenance costs (NPV over 50yrs)	€127,639.61
Detailed design (design fees) (6%)	€35,653.52
Construction supervision (5%)	€29,711.27
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€124,787.33
Cost of land acquisition/compensation (12.5%)	€74,278.17
allowance for art (1%)	€5,942.25
Project Whole Life Cost	€1,467,617.81

Summary

Total Damage	€22,453,691.00
Total Benefit	€12,273,611.00
Total Damage/Benefit	1.83
Total Construction Cost	€594,225.37
Project Whole Life Cost	€1,467,617.81
BCR	8.36
MCA	1220
MCA BCR	831.3

Appendix D

Multi Criteria Analysis

Criteria	Objective	Sub-Objective	Indicator	Basic Requirement	Aspirational Target	Global Weighting	Local Weighting	Local Weighting Comment	Score	Score Comment	Weighted Score	
							Local Importance 1	International Importance 5	Does not meet Basic Requirement -5	Meets Basic Requirement 0		Meets Aspirational Target 5
1	Technical	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	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully	20	5	Constant at 5	Operation to perform successfully will rely on proper maintenance of embankment, involving grass cutting, removing any blockages and maintaining hedges. Low level of operational risk	400
		b	Minimise health and safety risks associated with the construction and operation of flood risk 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	5	Constant at 5	Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations (-1) Electrical work (-1)	400
		c	Ensure flood risk management options are adaptable to future flood risk	i) Ensure flood risk management options are 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	5	Constant at 5	0 - option adaptable to MRFS with difficulty 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 5 - option provides HEFS	0
2	Economic	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	30	5	Constant at 5	Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during the 0.1% AEP event with a max score of 5 for 100%	150
		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	10	2	Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Minor Road - 1	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	20
		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	0	No utility infrastructure assets at risk	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		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	2	Sizable area at risk of local importance. Flow to be conveyed through channel on agricultural land, with total depth and storage of flood water on agricultural land reduced	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	40
3	Social	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	1	Due to low population	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	90
				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	1	No high vulnerability properties at risk during the 1% AEP event	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		b	Minimise risk to community	i) Minimise risk to social infrastructure	Number of high value social 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 assets at risk from flooding	5	1	No first responders, no major govt offices at risk during the 1% AEP event	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
				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	3	Medium density of commercial activity	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	60
		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	7 sports fields, in which flood depths total flood area have been reduced	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
4	Environmental	a	Support the objectives of the WFD	i) Prevent deterioration in status, and if possible contribute to the achievement of good 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 the achievement of good status/potential	10	5	WFD objectives must be achieved in all water bodies so this objective should always have the maximum local weighting	Reduction in flooding will reduce input of contaminants from the urbanised town catchment which could have benefits for water status	50
		b	Minimise the risk to potential sources of environmental pollution	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 92/271/EC)	No additional (or substitution of) potential pollution sources at risk from flooding due to the implementation of the flood risk management option	No potential pollution sources at risk from flooding due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent	Achieves basic target in that no additional receptors are put at risk	0
		c	Support the objectives of the Habitats Directive	i) Avoid damage to, and where possible enhance, European protected Natura 2000 sites	Reported conservation status of Natura 2000 sites relating to flood risk management	No deterioration in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent, AA has screened out any impacts	Achieves basic target in that no additional receptors are affected	0
		d	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	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	No deterioration in conservation status of sites due to the implementation of the flood risk management option	Improvement in conservation status of sites due to the implementation of the flood risk management option	2.5	1	No receptors in 1% AEP flood extent	Achieves basic target in that no additional receptors are affected	0
				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 species and other known species of conservation concern due to the implementation of the flood risk management option	2.5	3	No recorded legally protected species or known species of conservation in the subject area.	Achieves basic target in that no receptors are affected	0
		e	Protect, and where possible enhance, fisheries resource within the catchment	i) Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions 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	1	Nearby River Deelee, popular for angling, is not within reach of embankments. Proposal not suitable for fisheries	Achieves basic target in that no receptors are affected	0
				ii) Protect, and where possible enhance, the quality of shellfish waters	Classification of shellfish waters	No deterioration in shellfish water quality parameter values due to the implementation of the flood risk management option	Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option	2.5	1	Nearest shellfish area is Donegal Bay, not affected by proposal	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
		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	5	1	Agricultural catchment, no local amenities affected.	Embankments will possibly have a negative impact on landscape, although hard concrete defenses have been avoided.	-5
		g	Avoid damage to or loss of features of cultural heritage 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 Protected Structures (RPS) in the County Development Plans and 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 result of implementation of the option.	No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	Monuments in 1% AEP floodplain not at risk.	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
				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 additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a result of implementation of the option.	No archaeological heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	No architectural heritage at risk from flooding	Achieves basic target in that no receptors are affected	0
		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	5	3	Agricultural catchment outside town limit, with an urbanised town with some agricultural, grassed areas and amenities	Reduction of sheet like runoff conveyed through agricultural land.	15
		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	1	No flood sensitive environmental receptors at risk.	To be assessed at detailed design stage	0
												1220

MCA scoring calculations - Option 1

Objective		1%AEP	0.1%AEP	Score	rounded score
2a	AAD (€)	7416354.95	9589982.73	1.13	1
2b	Transport (no.)	1852	11867	0.78	1
2c	Utility (no.)	0	0	0.00	0
2d	Agricultural (km2)	578155.79	1894593.80	1.53	2
3ai	res props (no.)	167	325	2.57	3
3aii	vuln props (no.)	0	0	0.00	0
3bi	val props (no.)	0	0	0.00	0
3bii	Commercial (no.)	49	139	1.76	2
3ci	amenity sites (no.)	0	7	0.00	0
4bi	Polluting sites (no.)	0	0	0.00	0
4gi	Architecture (no.)	0	0	0	0
4gii	Archaeology (no.)	0	5	0.00	0

Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%

Criteria	Objective	Sub-Objective	Indicator	Basic Requirement	Aspirational Target	Global Weighting	Local Weighting	Local Weighting Comment	Score	Score Comment	Weighted Score		
							Local Importance	International Importance	Does not meet Basic Requirement	Meets Basic Requirement		Meets Aspirational Target	
													1
1	Technical	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	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully	20	5	Constant at 5	4	Operation to perform successfully will rely on proper maintenance of embankment, involving grass cutting, removing any blockages and maintaining hedges. Low level of operational risk	400
		b	Minimise health and safety risks associated with the construction and operation of flood risk 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	5	Constant at 5	2	Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations (-1) Electrical work (-1)	200
		c	Ensure flood risk management options are adaptable to future flood risk	i) Ensure flood risk management options are 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	5	Constant at 5	0	0 - option adaptable to MRFS with difficulty 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 5 - option provides HEFS	0
2	Economic	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	30	5	Constant at 5	1	Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during the 0.1% AEP event with a max score of 5 for 100%	150
		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	10	2	Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Minor Road - 1	1	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	20
		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	0	No utility infrastructure assets at risk	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		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	2	Sizable area at risk of local importance. Flow to be conveyed through channel on agricultural land, with total depth and storage of flood water on agricultural land reduced	2	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	40
3	Social	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	1	Due to low population	3	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	90
				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	1	No high vulnerability properties at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		b	Minimise risk to community	i) Minimise risk to social infrastructure	Number of high value social 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 assets at risk from flooding	5	1	No first responders, no major govt offices at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
				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	3	Medium density of commercial activity	2	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	60
		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	7 sports fields, in which flood depths total flood area have been reduced	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
4	Environmental	a	Support the objectives of the WFD	i) Prevent deterioration in status, and if possible contribute to the achievement of good 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 the achievement of good status/potential	10	5	WFD objectives must be achieved in all water bodies so this objective should always have the maximum local weighting	1	Reduction in flooding will reduce input of contaminants from the urbanised town catchment which could have benefits for water status	50
		b	Minimise the risk to potential sources of environmental pollution	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 92/271/EC)	No additional (or substitution of) potential pollution sources at risk from flooding due to the implementation of the flood risk management option	No potential pollution sources at risk from flooding due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent	0	Achieves basic target in that no additional receptors are put at risk	0
		c	Support the objectives of the Habitats Directive	i) Avoid damage to, and where possible enhance, European protected Natura 2000 sites	Reported conservation status of Natura 2000 sites relating to flood risk management	No deterioration in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent, AA has screened out any impacts	0	Achieves basic target in that no additional receptors are affected	0
		d	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	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	No deterioration in conservation status of sites due to the implementation of the flood risk management option	Improvement in conservation status of sites due to the implementation of the flood risk management option	2.5	1	No receptors in 1% AEP flood extent	0	Achieves basic target in that no additional receptors are affected	0
				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 species and other known species of conservation concern due to the implementation of the flood risk management option	2.5	3	No recorded legally protected species or known species of conservation in the subject area.	0	Achieves basic target in that no receptors are affected	0
		e	Protect, and where possible enhance, fisheries resource within the catchment	i) Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions 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	1	Nearby River Dee, popular for angling, is not within reach of embankments. Proposal not suitable for fisheries	0	Achieves basic target in that no receptors are affected	0
				ii) Protect, and where possible enhance, the quality of shellfish waters	Classification of shellfish waters	No deterioration in shellfish water quality parameter values due to the implementation of the flood risk management option	Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option	2.5	1	Nearest shellfish area is Donegal Bay, not affected by proposal	0	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
		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	5	1	Agricultural catchment, no local amenities affected.	-2	Retaining wall will possibly have a negative impact on landscape.	-10
		g	Avoid damage to or loss of features of cultural heritage 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 Protected Structures (RPS) in the County Development Plans and 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 result of implementation of the option.	No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	Monuments in 1% AEP floodplain not at risk.	0	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
				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 additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a result of implementation of the option.	No archaeological heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	No architectural heritage at risk from flooding	0	Achieves basic target in that no receptors are affected	0
		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	5	3	Agricultural catchment outside town limit, with an urbanised town with some agricultural, grassed areas and amenities.	1	Reduction of sheet like runoff conveyed through agricultural land.	15
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	1	No flood sensitive environmental receptors at risk.	0	To be assessed at detailed design stage	0		

MCA scoring calculations - Option 2

Objective		1%AEP	0.1%AEP	Score	rounded score
2a	AAD (€)	7416354.95	9589982.73	1.13	1
2b	Transport (no.)	1852	11867	0.78	1
2c	Utility (no.)	0	0	0.00	0
2d	Agricultural (km2)	578155.79	1894593.80	1.53	2
3ai	res props (no.)	167	325	2.57	3
3aii	vuln props (no.)	0	0	0.00	0
3bi	val props (no.)	0	0	0.00	0
3bii	Commercial (no.)	49	139	1.76	2
3ci	amenity sites (no.)	0	7	0.00	0
4bi	Polluting sites (no.)	0	0	0.00	0
4gi	Architecture (no.)	0	0	0	0
4gii	Archaeology (no.)	0	5	0.00	0

Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%

Criteria	Objective	Sub-Objective	Indicator	Basic Requirement	Aspirational Target	Global Weighting	Local Weighting	Local Weighting Comment	Score	Score Comment			Weighted Score
							Local Importance	International Importance	Does not meet Basic Requirement	Meets Basic Requirement	Meets Aspirational Target		
							1	5	-5	0	5		
1	Technical	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	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully	20	5	Constant at 5	4	Operation to perform successfully should not require human intervention, with no electrical systems in place	400
		b	Minimise health and safety risks associated with the construction and operation of flood risk 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	5	Constant at 5	-2	Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations (-1) Electrical work (-1)	-200
		c	Ensure flood risk management options are adaptable to future flood risk	i) Ensure flood risk management options are 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	5	Constant at 5	0	0 - option adaptable to MRFS with difficulty 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 5 - option provides HEFS	0
2	Economic	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	30	5	Constant at 5	1	Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during the 0.1% AEP event with a max score of 5 for 100%	150
		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	10	2	Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Minor Road - 1	1	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	20
		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	0	No utility infrastructure assets at risk	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		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	1	Sizeable area at risk of local importance. Water to be stored over large area of agricultural land up to depths up to 6 meters will cause disruption to agricultural activities and possibly pose a health issue to animals. Greater flood depths will be experienced over a large area of agricultural land	1	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	10
3	Social	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	1	Due to low population	3	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	90
				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	1	No high vulnerability properties at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		b	Minimise risk to community	i) Minimise risk to social infrastructure	Number of high value social 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 assets at risk from flooding	5	1	No first responders, no major govt offices at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
				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	3	Medium density of commercial activity	2	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	60
		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	7 sports fields, in which flood depths total flood area have been reduced	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
4	Environmental	a	Support the objectives of the WFD	i) Prevent deterioration in status, and if possible contribute to the achievement of good 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 the achievement of good status/potential	10	5	WFD objectives must be achieved in all water bodies so this objective should always have the maximum local weighting	1	Reduction in flooding will reduce input of contaminants from the urbanised town catchment which could have benefits for water status	50
		b	Minimise the risk to potential sources of environmental pollution	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 92/271/EC)	No additional (or substitution of) potential pollution sources at risk from flooding due to the implementation of the flood risk management option	No potential pollution sources at risk from flooding due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent	0	Achieves basic target in that no additional receptors are put at risk	0
		c	Support the objectives of the Habitats Directive	i) Avoid damage to, and where possible enhance, European protected Natura 2000 sites	Reported conservation status of Natura 2000 sites relating to flood risk management	No deterioration in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent, AA has screened out any impacts	0	Achieves basic target in that no additional receptors are affected	0
		d	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	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	No deterioration in conservation status of sites due to the implementation of the flood risk management option	Improvement in conservation status of sites due to the implementation of the flood risk management option	2.5	1	No receptors in 1% AEP flood extent	0	Achieves basic target in that no additional receptors are affected	0
				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 species and other known species of conservation concern due to the implementation of the flood risk management option	2.5	3	No recorded legally protected species or known species of conservation in the subject area.	0	Achieves basic target in that no receptors are affected	0
		e	Protect, and where possible enhance, fisheries resource within the catchment	i) Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions 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	1	Nearby River Deelee, popular for angling, is not within reach of embankments. Proposal not suitable for fisheries	0	Achieves basic target in that no receptors are affected	0
				ii) Protect, and where possible enhance, the quality of shellfish waters	Classification of shellfish waters	No deterioration in shellfish water quality parameter values due to the implementation of the flood risk management option	Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option	2.5	1	Nearest shellfish area is Donegal Bay, not affected by proposal	0	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
		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	5	1	Agricultural catchment, no local amenities affected.	-4	Large storage wall up to a height of several meters is likely to have a negative impact on landscape character of the catchment.	-20
		g	Avoid damage to or loss of features of cultural heritage 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 Protected Structures (RPS) in the County Development Plans and 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 result of implementation of the option.	No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	Monuments in 1% AEP floodplain not at risk.	0	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
				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 additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a result of implementation of the option.	No archaeological heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	2	No architectural heritage at risk from flooding	0	Achieves basic target in that no receptors are affected	0
		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	5	3	Agricultural catchment outside town limit, with an urbanised town with some agricultural, grassed areas and amenities.	0	Storage wall would reduce depths of sheet like runoff conveyed through agricultural land and the town, although storing sizeable depths of water on agricultural land may have detrimental impacts.	0
		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	1	No flood sensitive environmental receptors at risk.	0	To be assessed at detailed design stage	0
													560

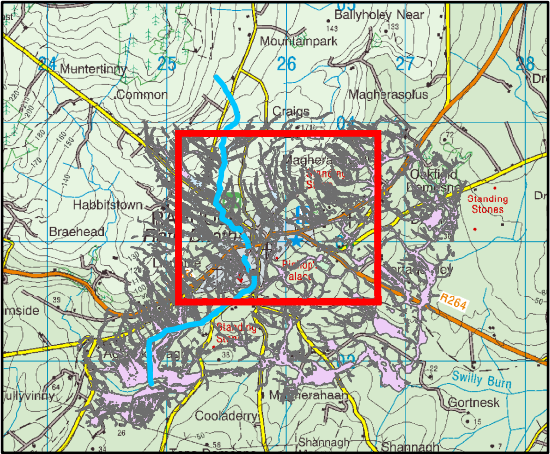
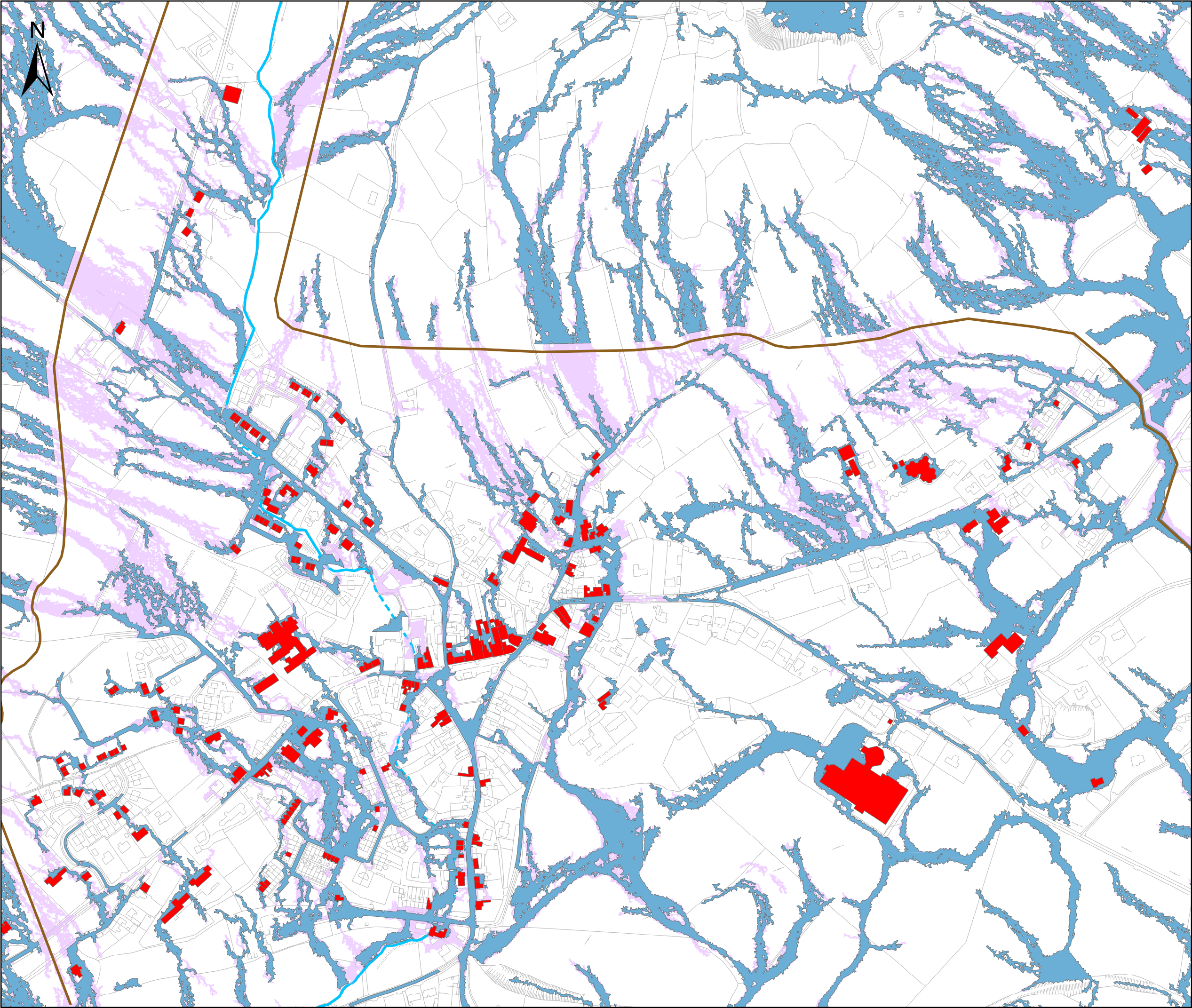
MCA scoring calculations - Option 3

Objective		1%AEP	0.1%AEP	Score	rounded score
2a	AAD (€)	7416354.95	9589982.73	1.13	1
2b	Transport (no.)	1743	11867	0.73	1
2c	Utility (no.)	0	0	0.00	0
2d	Agricultural (km2)	556077.19	1894593.80	1.47	1
3ai	res props (no.)	167	325	2.57	3
3aii	vuln props (no.)	0	0	0.00	0
3bi	val props (no.)	0	0	0.00	0
3bii	Commercial (no.)	49	139	1.76	2
3ci	amenity sites (no.)	0	7	0.00	0
4bi	Polluting sites (no.)	0	0	0.00	0
4gi	Architecture (no.)	0	0	0	0
4gii	Archaeology (no.)	0	5	0.00	0

Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%

Appendix E

Residual Risk Maps and Secondary Measures



"The viewer of this map should refer to the Disclaimer, Guidance Notes and Conditions of Use that accompany this map."

Legend

FRM Measures

Primary Embankment

Properties at Risk

Threshold > 300mm

Flood Extents Q100

Primary Measure

Current

Watercourse

Open channel watercourse

Culverted watercourse



FINAL

TITLE
RAPHOE
Figure 6.2 - Residual Risk After Primary Measure

CLIENT PROJECT
RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY



Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

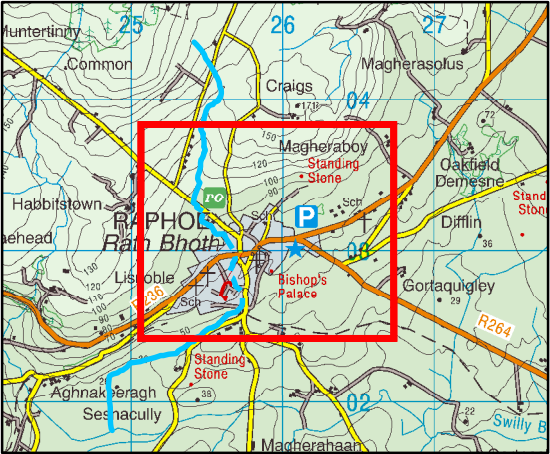
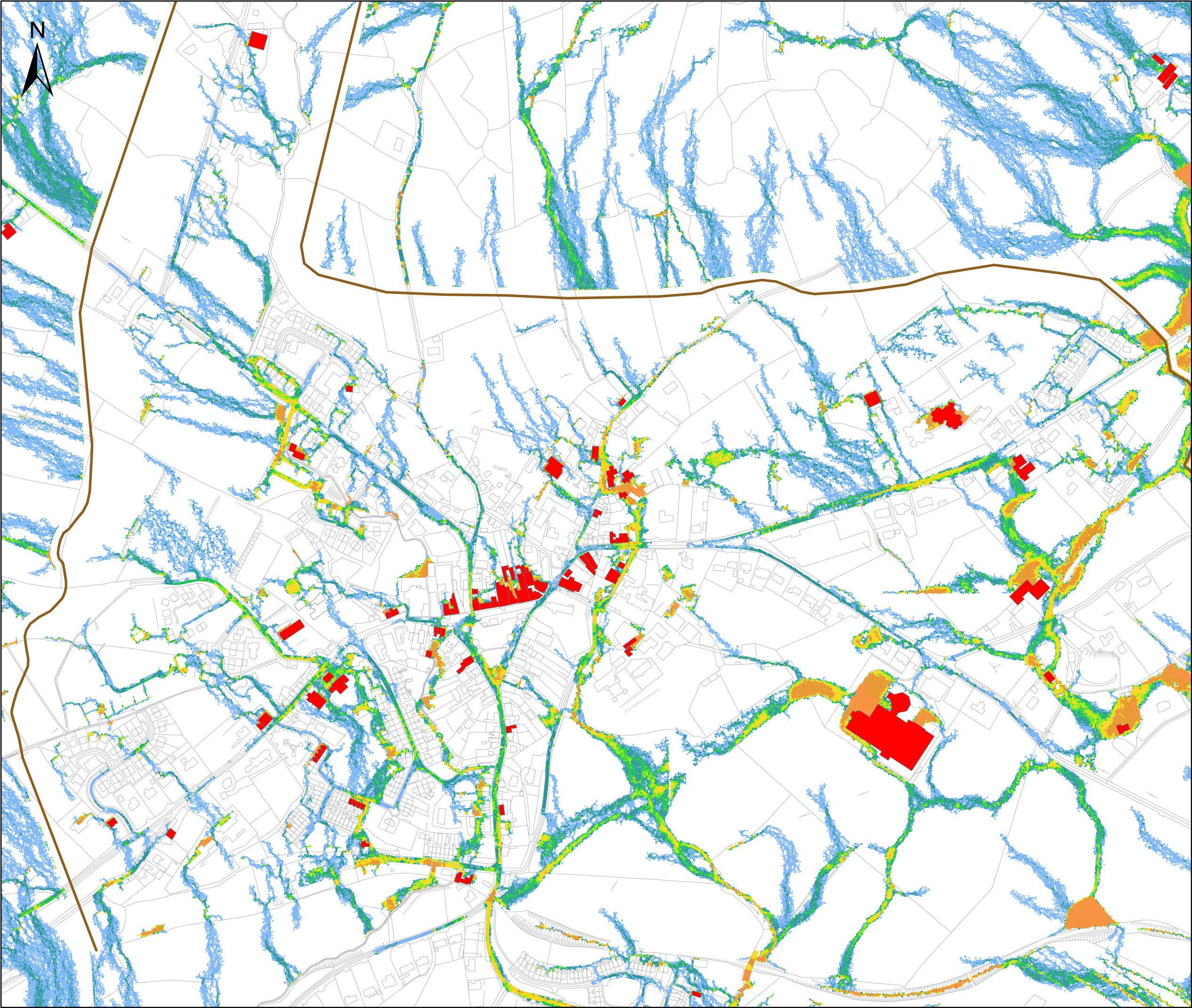
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IBE0809_RAPHOE_FIGURE_6.2

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Kilometers

SCALE AT A3:1:5,000

Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 16/09/2014



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Legend

FRM Measures

Primary Embankment

Properties at Risk

Threshold value > 0mm

Primary Flood Extent (m)

0.01 - 0.025

0.025 - 0.05

0.05 - 0.075

0.075 - 0.10

0.10 - 0.20

0.20 - 0.50

> 0.5



FINAL

TITLE
RAPHOE
Figure 6.3 - Primary Q100 Flood Extent
Showing Properties at Risk

CLIENT PROJECT
RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY



Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

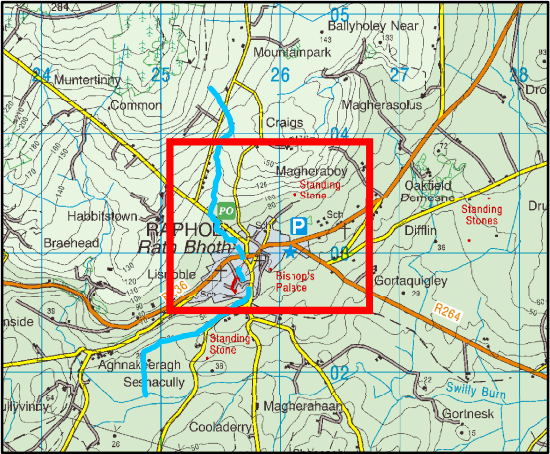
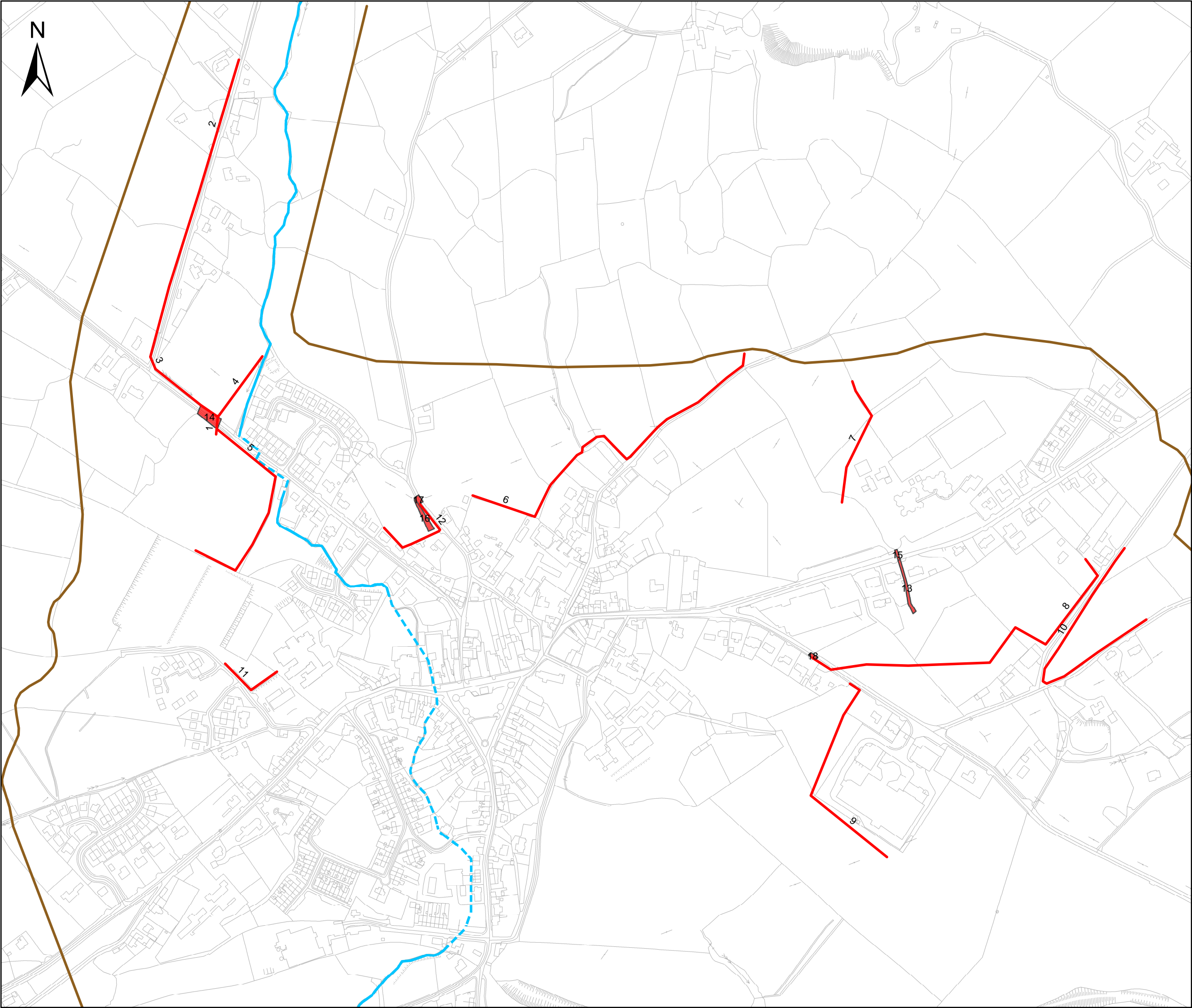
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IBE0809_RAPHOE_FIGURE_6.5

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Kilometers

SCALE AT A3:1:5,000

Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 16/09/2014



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Legend

FRM Measures

- Primary Embankment
- Storage and Diversion
- Reprofilling and Diversion

Watercourse

- Open channel watercourse
- Culverted watercourse



FINAL

TITLE
RAPHOE
Figure 6.4 - Location of Secondary Measures

CLIENT PROJECT
RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY



Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

Drawing No. :

IBE0809_RAPHOE_FIGURE_6.3

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Kilometers

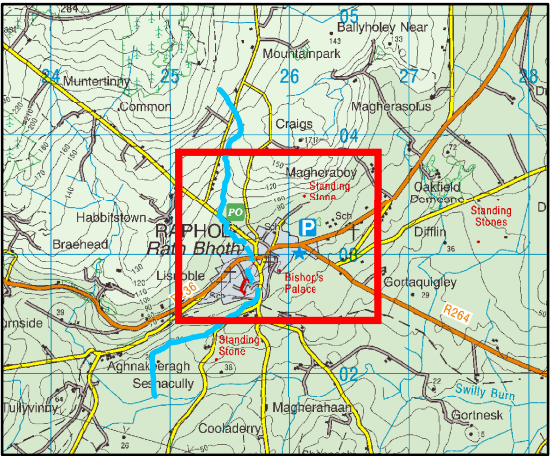
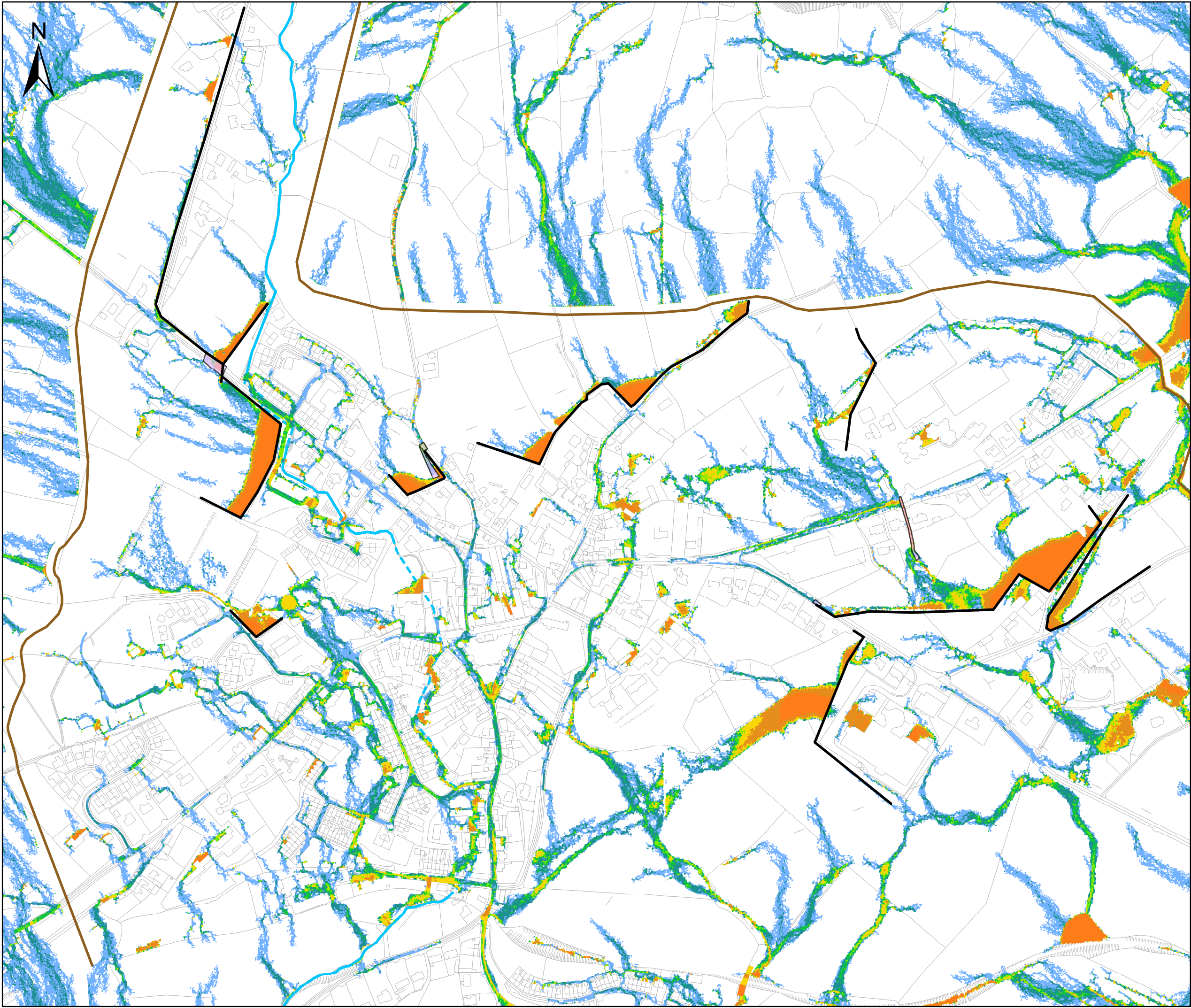
SCALE AT A3:1:5,000

Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 16/09/2014

Figure 6.2 Comments - Secondary Measures

Measure No	Shape	Comment	Length (m)
1	Polyline	Culvert	26.088
2	Polyline	Existing Ditch - Make Larger	435.953
3	Polyline	Culvert to Connect Ditches	18.566
4	Polyline	Existing Ditch - Make Larger	216.217
5	Polyline	Storage Ditch	314.077
6	Polyline	Storage Ditch	522.336
7	Polyline	Burn to Direct Flow	186.446
8	Polyline	Storage Ditch	515.371
9	Polyline	Burn to Direct Flow	317.924
10	Polyline	Storage Ditch	394.415
11	Polyline	Storage Ditch	96.495
12	Polyline	Storage Ditch	142.291

Measure No	Shape	Comment	Area (m ²)
13	Polygon	Lower Existing Lane	281.45
14	Polygon	Road Reprofile	478.166
15	Polygon	Road Reprofile	52.265
16	Polygon	Landscaping to Direct Flow	269.293
17	Polygon	Road Reprofile	80.54
18	Polygon	Cattle Grid	52.468



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Legend

FRM Measures

- Primary Embankment
- Storage and Diversion
- Reprofiling and Diversion

Prim+Sec Q100 Flood Depths (m)

- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50

Watercourse

- Open channel watercourse
- Culverted watercourse

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TITLE **RAPHOE**
Figure 6.5 - Primary and Secondary Q100 Flood Extent

CLIENT PROJECT

OPW
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Oifig na nUachtarach Poblai

RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

RPS

Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

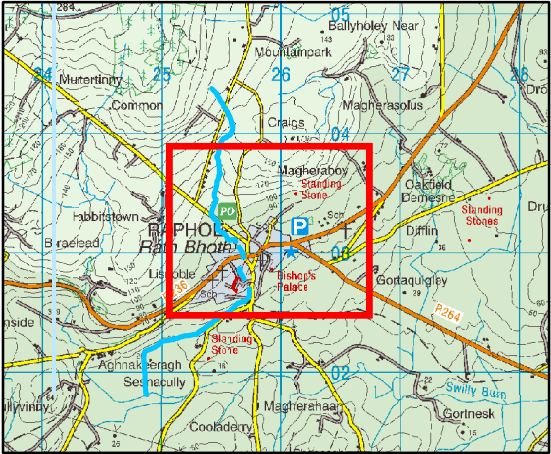
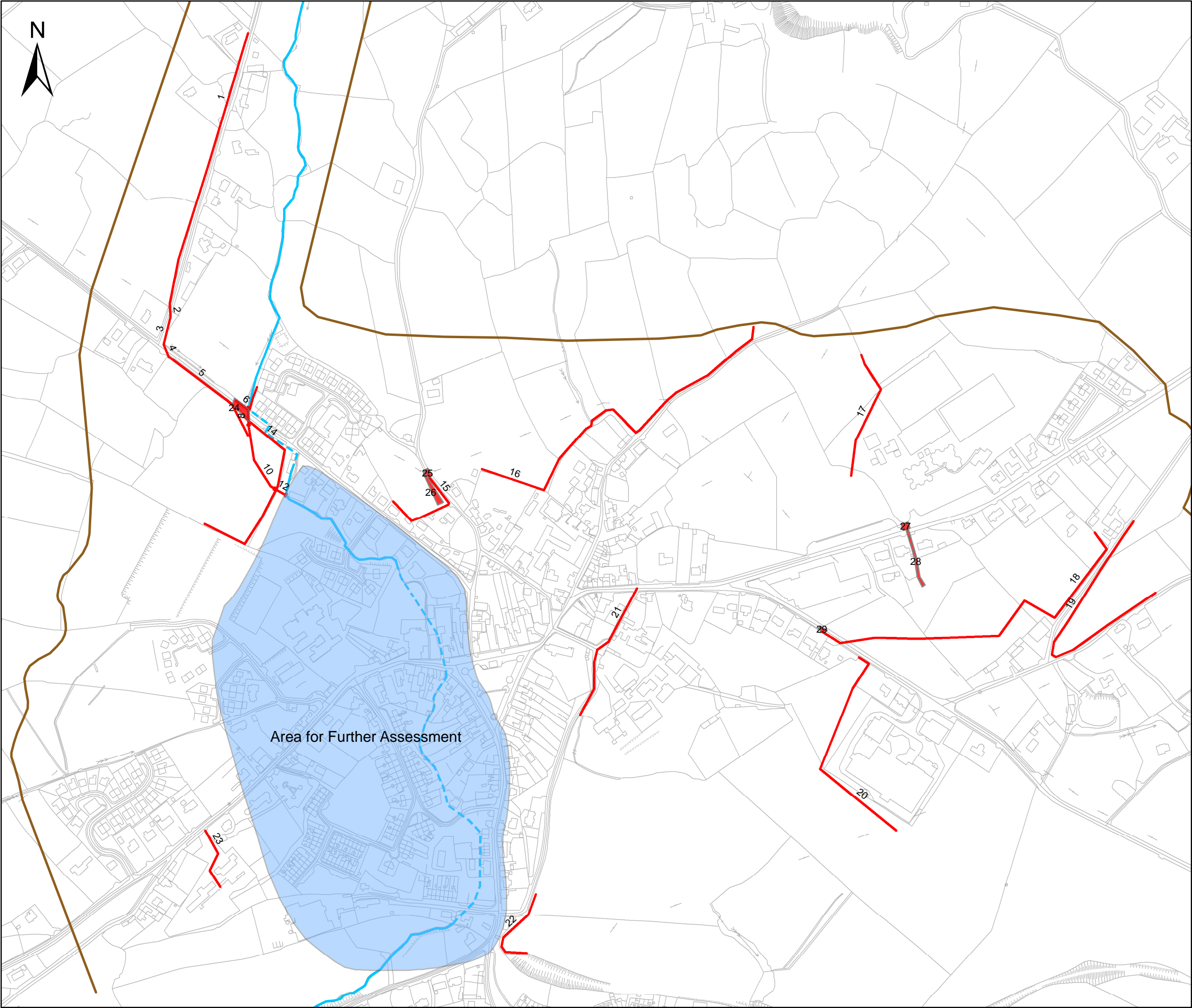
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Drawing No. :
IBE0809_RAPHOE_FIGURE_6.4

0 0.05 0.1 0.2
Kilometers

SCALE AT A3:1:5,000

Drawn By : JD
Checked By : AJ
Approved By : AJ
Date : 16/09/2014



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Legend

FRM Measures

- Primary Embankment
- Area for Further Assessment
- Road and land reprofiling
- Embankments, Walls and Culverts

Watercourse

- Open channel watercourse
- Culverted watercourse



FINAL

TITLE
RAPHOE
Figure 6.6 - Location of Refined
Secondary Measures

CLIENT PROJECT
**RAPHOE CATCHMENT FLOOD
RISK ASSESSMENT
AND MANAGEMENT
STUDY**



Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44 (0) 28 90 667914
F +44 (0) 28 90 668286
W www.rpsgroup.com
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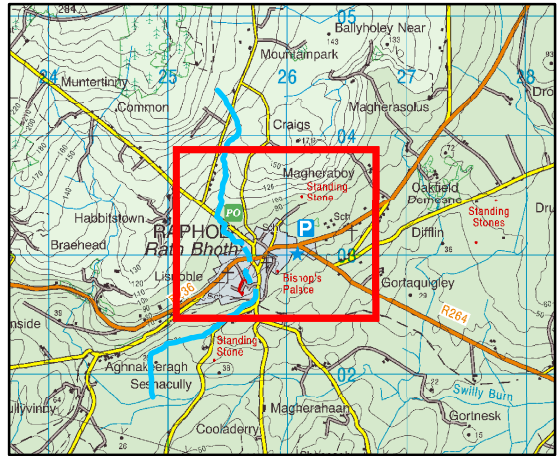
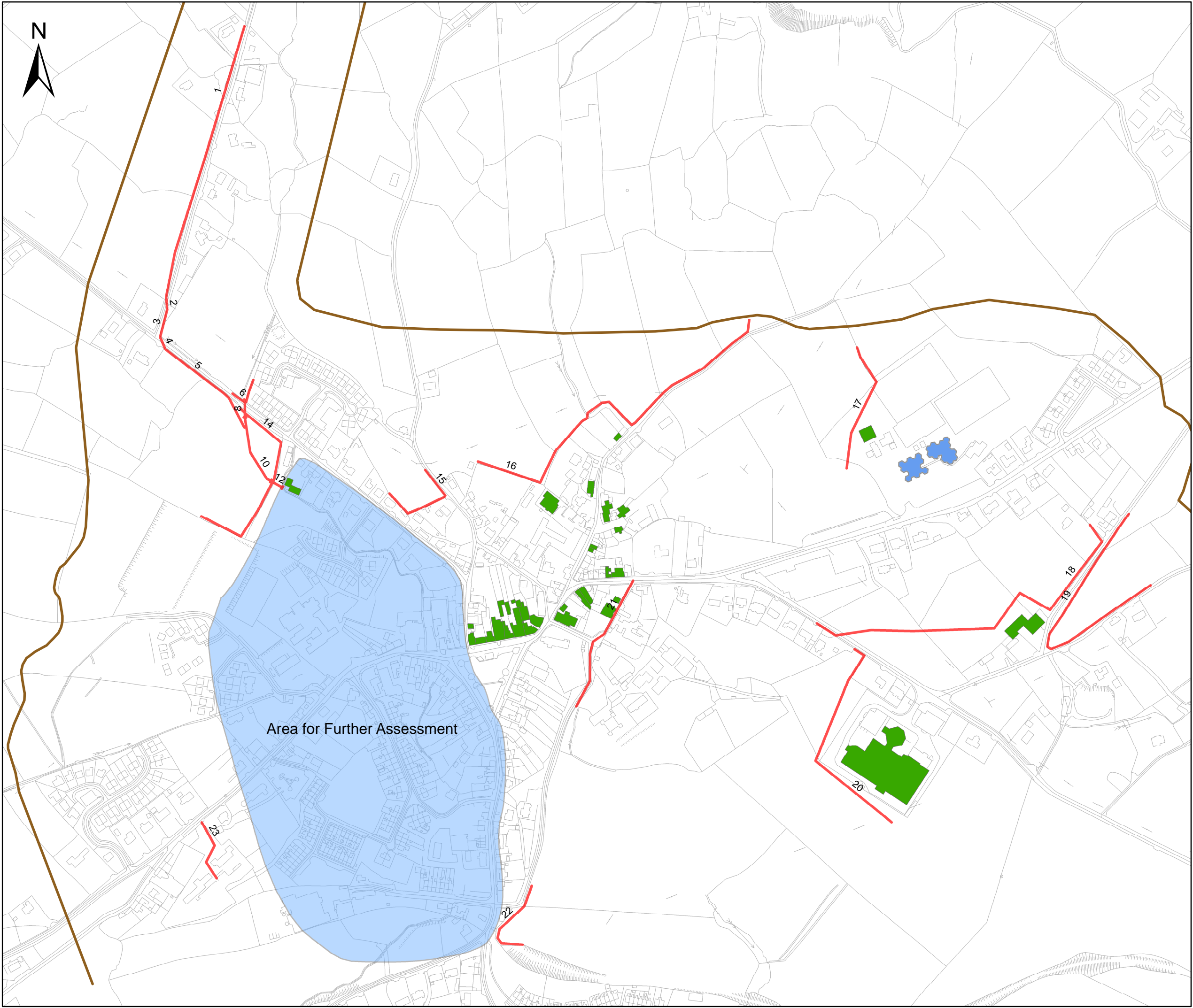
Drawing No. :

IBE0809_RAPHOE_FIGURE_6.6

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Kilometers

SCALE AT A3:1:5,000

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Checked By : AJ
Approved By : AJ
Date : 16/09/2014



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Legend

FRM Measures


- Primary Embankment
- Embankments, Walls and Culverts

Properties Identified

- Predicted to Benefit
- Unlikely to be at Risk


Designations

- Area for Further Assessment


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FINAL

TITLE **RAPHOE**
Figure 6.7 - Properties Predicted to be Protected by Secondary Measures

CLIENT	PROJECT
	RAPHOE CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT STUDY

	Elmwood House	T	+44 (0) 28 90 667914
	74 Boucher Road	F	+44 (0) 28 90 668286
	Belfast	W	www.rpsgroup.com
	BT12 6RZ	E	ireland@rpsgroup.com

Drawing No. : IBE0809_RAPHOE_FIGURE_6.7	Drawn By : JD Checked By : AJ Approved By : AJ Date : 16/09/2014
	0 0.05 0.1 0.2 Kilometers
SCALE AT A3:1:5,000	

Appendix F

Secondary Measures - Hydrology Calculations

Raphoe FRAM Study, Secondary Measures**Measure No. Description**

Drainage 1	Clean stone drain behind Beechwood Ave, picking up stream and diverting and discharging to new channel.
Drainage 2	New pipe in Derry Road, gullies at bus layby to catch runoff. Discharge to new channel.
Drainage 3	New pipe in Castle Road (North), new gullies at upstream extent. Discharge to D8.
Drainage 4	New pipe through the Diamond, new gullies in Diamond and Irish Row. Discharge to D8.
Drainage 5	New gullies and ramp at boxing club, raised kerbs at McCullagh's Corner, new pipe on Guesthouse End. Discharge to D9.
Drainage 6	New pipe in Meetinghouse Street and gullies where required. Discharge to D10.
Drainage 7	Divert pipe from Cathedral Hill to D10, collect runoff from school at entrance with gullies and discharge to D10.
Drainage 10	Existing 450mm/600mm pipe - upgrade to take 6&7. Gullies at low point in green. Discharge to watercourse.
Drainage 8	New pipe in Castle Road (South) + D3 + D4. Discharge to D9.
Drainage 9	D8 + D5 discharging to watercourse.
Secondary 5	Divert flow into field, open channel, new road culvert.
Secondary 12	Embankment to create storage area beside Irish Row.
Secondary 6	Embankment to create storage area above town.
Secondary 8	Embankment to create storage area south of Derry Road.
Secondary 10	Storage ditch.

Additional drainage measures:

Ramps and gullies along Derry Road

Embankments at disused quarry to convey flow past nursery and new house

Ramp and gully at Castle View

Ramps and gullies on Killygordon Road

Ramps and gullies at primary school

Embankment and drain at old railway

Take runoff from road south of railway

Areas within each Depth Duration Frequency Model Grid (Flood Studies Update)

Measure No.	Area (m ²)			
	DDF 3	DDF 4	DDF 6	Total
Drainage 1	17799	16636		34435
Drainage 2	26815	109249		136064
Drainage 3	5356	63369	2572	71297
Drainage 4		78851	1047	79898
Drainage 5		42240		42240
Drainage 6		46435		46435
Drainage 7		76395	28049	104444
Drainage 10				0
Drainage 8		15148		15148
Drainage 9				0
Secondary 5		7957	81795	89752
Secondary 12		23160	2642	25802
Secondary 6	10725	14270	26647	51642
Secondary 8	13000	50694		63694
Secondary 10	8503			8503

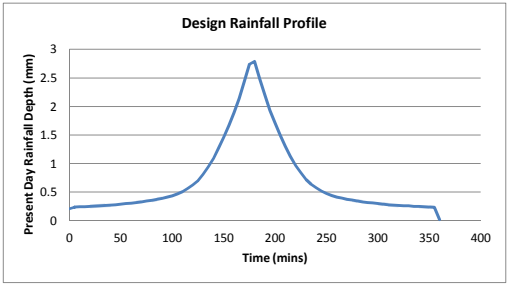
Drainage 1 Clean stone drain behind Beechwood Ave, picking up stream and diverting and discharging to new channel.

Catchment Area (DDF3):	17799.00 m ²
Volume	925.26 m ³
Flow	0.17 m ³ /s

Design Rainfall Profile DDF3

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.01241387	12.41387016	3.72	
5	0.004583334	0.238258552	2.859102619	0.01413588	14.13587987	4.24	7.96
10	0.004686111	0.243601298	2.923215574	0.014452865	14.452865	4.34	12.30
15	0.004763887	0.247644386	2.971732627	0.014692741	14.6927414	4.41	16.71
20	0.004861112	0.252698489	3.03238187	0.014992601	14.99260136	4.50	21.21
25	0.004980555	0.258907581	3.106890978	0.015360987	15.36098681	4.61	25.81
30	0.005058334	0.262950809	3.155409703	0.015600871	15.60087147	4.68	30.49
35	0.00514444	0.26742693	3.20912316	0.01586644	15.86643976	4.76	35.25
40	0.005269449	0.273925362	3.287104342	0.016251992	16.25199172	4.88	40.13
45	0.005352775	0.278256953	3.339083434	0.016508985	16.50898501	4.95	45.08
50	0.005544445	0.28822063	3.458647556	0.01710013	17.10012996	5.13	50.21
55	0.005747224	0.29876187	3.585142445	0.017725542	17.72554177	5.32	55.53
60	0.005927781	0.308147844	3.697774126	0.018282412	18.28241157	5.48	61.02
65	0.00613055	0.318688527	3.824262326	0.01890779	18.90779032	5.67	66.69
70	0.006319447	0.328508092	3.9420971	0.019490385	19.49038508	5.85	72.54
75	0.006616663	0.343958488	4.127501851	0.020407057	20.40705707	6.12	78.66
80	0.006897222	0.358542956	4.302515466	0.021272354	21.2725355	6.38	85.04
85	0.007169442	0.372693972	4.47232766	0.022111933	22.1193334	6.63	91.67
90	0.007522224	0.391032885	4.692394616	0.023199981	23.19998105	6.96	98.63
95	0.007905558	0.41095996	4.931519514	0.024382254	24.3822544	7.31	105.95
100	0.008388888	0.43608525	5.233023002	0.025872938	25.87293789	7.76	113.71
105	0.009038889	0.469874698	5.638496382	0.027877666	27.87766586	8.36	122.07
110	0.009766669	0.507707374	6.092488487	0.030122278	30.12227849	9.04	131.11
115	0.010833329	0.56315631	6.757875725	0.033412064	33.4120639	10.02	141.13
120	0.012074993	0.627702578	7.532430932	0.037241594	37.24159393	11.17	152.31
125	0.01347777	0.700624081	8.407488974	0.041568027	41.56802673	12.47	164.78
130	0.01565556	0.813833604	9.76600325	0.048284748	48.28474773	14.49	179.26
135	0.018058345	0.938739217	11.26487061	0.055695398	55.69539776	16.71	195.97
140	0.020961119	1.089636049	13.07563259	0.064648107	64.6481068	19.39	215.36
145	0.024561118	1.276777255	15.32132706	0.075751195	75.75119455	22.73	238.09
150	0.028000015	1.455543783	17.46652539	0.086357413	86.35741262	25.91	264.00
155	0.032116631	1.669540602	20.03448723	0.099053844	99.05384392	29.72	293.71
160	0.036388911	1.891629451	22.69955341	0.112230375	112.2303753	33.67	327.38
165	0.041183274	2.140858096	25.69029715	0.127017111	127.0171108	38.11	365.49
170	0.04689447	2.437747064	29.25296477	0.144631533	144.6315333	43.39	408.88
175	0.052650006	2.736940993	32.84329191	0.162382709	162.3827091	48.71	457.59
180	0.053594459	2.786037143	33.43244571	0.165295584	165.2955837	49.59	507.18
185	0.047805573	2.485109547	29.82131456	0.147441549	147.4415494	44.23	551.41
190	0.042461136	2.207286045	26.48743255	0.130958281	130.9582811	39.29	590.70
195	0.037199995	1.933792602	23.20551123	0.114731915	114.7319151	34.42	625.12
200	0.032949952	1.712859718	20.55431662	0.101623967	101.6239671	30.49	655.61
205	0.028888919	1.501752252	18.02102702	0.089098961	89.0989611	26.73	682.34
210	0.025061063	1.302766244	15.63319493	0.077293121	77.29312125	23.19	705.52
215	0.021772251	1.131801709	13.58162051	0.067149795	67.14979541	20.14	725.67
220	0.018552775	0.964441515	11.57329817	0.057220315	57.22031506	17.17	742.84
225	0.016108339	0.837370733	10.0484488	0.049681206	49.68120559	14.90	757.74
230	0.013913924	0.723296955	8.679563455	0.042913208	42.91320831	12.87	770.61
235	0.012269456	0.637811482	7.65373778	0.037841355	37.84135521	11.35	781.97
240	0.011099976	0.577017569	6.924210827	0.034234452	34.23445237	10.27	792.24
245	0.009944458	0.516949514	6.203394165	0.030670615	30.67061465	9.20	801.44
250	0.00916666	0.476516685	5.718200221	0.028271735	28.27173493	8.48	809.92
255	0.008530533	0.443448495	5.32138194	0.026309799	26.30979921	7.89	817.81
260	0.007969432	0.414280395	4.971364744	0.024579256	24.57925585	7.37	825.19
265	0.007605556	0.395364754	4.744377054	0.023456991	23.45699088	7.04	832.22
270	0.007225016	0.375582907	4.506994883	0.022283334	22.2833387	6.69	838.91
275	0.006955584	0.361576839	4.338922071	0.021452354	21.45235387	6.44	845.34
280	0.00668609	0.347567566	4.170810792	0.020621184	20.62118369	6.19	851.53
285	0.006358347	0.330530263	3.966363152	0.01961036	19.61036049	5.88	857.41
290	0.006169396	0.320707911	3.848494929	0.0190276	19.02760034	5.71	863.12
295	0.005972236	0.310458797	3.725505563	0.01841952	18.41952042	5.53	868.65
300	0.005775014	0.300206477	3.602477729	0.01781125	17.81125031	5.34	873.99
305	0.005591637	0.290673883	3.488086597	0.017245681	17.24568149	5.17	879.16
310	0.005388903	0.280135012	3.36162014	0.01662041	16.62041024	4.99	884.15
315	0.005277798	0.274359371	3.292312453	0.016277741	16.27774149	4.88	889.03
320	0.005163876	0.268437249	3.221246988	0.015926382	15.92638198	4.78	893.81
325	0.005086091	0.264393743	3.172724917	0.015686481	15.68648078	4.71	898.52
330	0.004997218	0.259773788	3.117285458	0.015412379	15.41237885	4.62	903.14
335	0.004872271	0.253278562	3.039342743	0.015027017	15.02701708	4.51	907.65
340	0.004791669	0.249088574	2.989062893	0.014778425	14.77842512	4.43	912.08
345	0.004711067	0.244898587	2.938783044	0.014529833	14.52983317	4.36	916.44
350	0.004586117	0.238403221	2.860838656	0.014144463	14.14446312	4.24	920.69
355	0.004497246	0.233783406	2.80540087	0.013870369	13.87036947	4.16	924.85
360	0.000444422	0.023102701	0.277232418	0.001370683	1.370683279	0.41	925.26

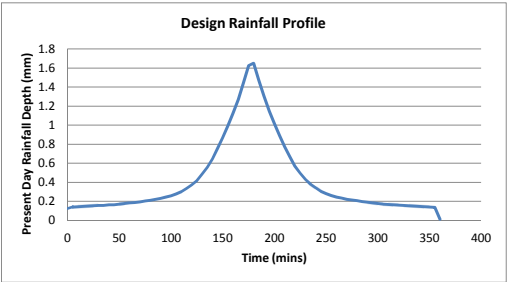


Drainage 1 Clean stone drain behind Beechwood Ave, picking up stream and diverting and discharging to new channel.

Catchment Area (DDF4):	16636.00 m ²
Volume	512.48 m ³
Flow	0.09 m ³ /s

Design Rainfall Profile DDF4
100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.006875795	6.875795356	2.06	
5	0.004583334	0.141192274	1.694307286	0.007829582	7.829582226	2.35	4.41
10	0.004686111	0.144358391	1.732300692	0.008005154	8.005153977	2.40	6.81
15	0.004763887	0.146754329	1.76105195	0.008138017	8.138016733	2.44	9.25
20	0.004861112	0.149749396	1.796992757	0.008304103	8.304103194	2.49	11.75
25	0.004980555	0.153428911	1.841146934	0.008508145	8.508144554	2.55	14.30
30	0.005058334	0.155824932	1.869899183	0.008641012	8.64101189	2.59	16.89
35	0.00514444	0.158477486	1.901729835	0.008788105	8.788104871	2.64	19.53
40	0.005269449	0.162328464	1.947941567	0.009001654	9.001654421	2.70	22.23
45	0.005352775	0.164895369	1.978744433	0.009143998	9.143997887	2.74	24.97
50	0.005544445	0.170799855	2.04959826	0.009471421	9.471421294	2.84	27.81
55	0.005747224	0.177046606	2.124559268	0.009817824	9.81782444	2.95	30.76
60	0.005927781	0.182608744	2.191304923	0.010126264	10.12626353	3.04	33.80
65	0.00613055	0.188855164	2.266261966	0.010472648	10.47264835	3.14	36.94
70	0.006319447	0.194674248	2.33609098	0.010795336	10.79533598	3.24	40.18
75	0.006616663	0.20383017	2.445962035	0.011303062	11.30306234	3.39	43.57
80	0.006897222	0.212472941	2.549675291	0.011782333	11.78233282	3.53	47.10
85	0.007169442	0.220858848	2.65030618	0.012247359	12.24735934	3.67	50.78
90	0.007522224	0.231726508	2.780718095	0.012850007	12.85000729	3.86	54.63
95	0.007905558	0.243535314	2.922423766	0.013504845	13.50484494	4.05	58.68
100	0.008388888	0.258424588	3.101095058	0.014330505	14.33050483	4.30	62.98
105	0.009038889	0.278448252	3.341379018	0.015440884	15.44088371	4.63	67.61
110	0.009766669	0.300867936	3.610415228	0.01668413	16.68412993	5.01	72.62
115	0.010833329	0.333727035	4.004724421	0.018506277	18.50627652	5.55	78.17
120	0.012074993	0.371977222	4.463726669	0.020627377	20.62737691	6.19	84.36
125	0.01347777	0.415190584	4.982287006	0.023023702	23.02370184	6.91	91.27
130	0.01565556	0.482278669	5.787344026	0.02674396	26.74395978	8.02	99.29
135	0.018058345	0.55629787	6.675574435	0.030848571	30.84857119	9.25	108.54
140	0.020961119	0.645719494	7.748633932	0.035807298	35.80729836	10.74	119.29
145	0.024561118	0.756619574	9.079434891	0.041957077	41.95707746	12.59	131.87
150	0.028000015	0.862556811	10.35068173	0.04783165	47.83165034	14.35	146.22
155	0.032116631	0.989371556	11.87245867	0.054863951	54.86395068	16.46	162.68
160	0.036388911	1.120981646	13.45177976	0.062162169	62.1621689	18.65	181.33
165	0.041183274	1.268674809	15.22409771	0.070352247	70.3522471	21.11	202.44
170	0.04689447	1.444611531	17.33533838	0.080108525	80.10852479	24.03	226.47
175	0.052650006	1.621914175	19.4629701	0.089940547	89.94054739	26.98	253.45
180	0.053594459	1.651008606	19.81210328	0.091553931	91.55393059	27.47	280.92
185	0.047805573	1.472678589	17.67214307	0.081664937	81.66493671	24.50	305.42
190	0.042461136	1.308040084	15.69648101	0.072535183	72.53518278	21.76	327.18
195	0.037199995	1.145967575	13.7516109	0.063547722	63.54772195	19.06	346.24
200	0.032949952	1.015042511	12.18051013	0.056287491	56.28749068	16.89	363.13
205	0.028888919	0.889939999	10.67927999	0.049350139	49.35013942	14.81	377.93
210	0.025061063	0.772020677	9.264248123	0.04281112	42.81111994	12.84	390.78
215	0.021772251	0.67070691	8.048482919	0.037192934	37.19293384	11.16	401.93
220	0.018552775	0.571529079	6.858348942	0.031693193	31.6931925	9.51	411.44
225	0.016108339	0.496226797	5.954721561	0.02751743	27.51742997	8.26	419.70
230	0.013913924	0.428626553	5.143518636	0.023768771	23.76877112	7.13	426.83
235	0.012269456	0.37796777	4.535613238	0.020959573	20.95957273	6.29	433.12
240	0.011099976	0.341941232	4.103294781	0.018961781	18.96178111	5.69	438.80
245	0.009944458	0.306344838	3.676138052	0.016987842	16.9878424	5.10	443.90
250	0.00916666	0.2823843	3.388611599	0.015659151	15.65915071	4.70	448.60
255	0.008530533	0.262788055	3.153456659	0.014572474	14.57247361	4.37	452.97
260	0.007969432	0.245503008	2.946036092	0.01361396	13.61396012	4.08	457.05
265	0.007605556	0.234293579	2.811522943	0.01299236	12.99235991	3.90	460.95
270	0.007225016	0.222570834	2.670850014	0.012342295	12.34229467	3.70	464.65
275	0.006955584	0.214270824	2.571249885	0.011882031	11.88203141	3.56	468.22
280	0.00668609	0.205968913	2.47162696	0.011421663	11.42166281	3.43	471.65
285	0.006358347	0.195872589	2.350471069	0.010861788	10.86178797	3.26	474.90
290	0.006169396	0.190051853	2.280622233	0.010539009	10.53900874	3.16	478.07
295	0.005972236	0.183978217	2.207738602	0.010202205	10.20220538	3.06	481.13
300	0.005775014	0.177902681	2.134832176	0.009865297	9.865296689	2.96	484.09
305	0.005591637	0.172253656	2.067043868	0.009552039	9.552039386	2.87	486.95
310	0.005388903	0.166008309	1.992099709	0.009205714	9.205714101	2.76	489.71
315	0.005277798	0.162585658	1.9510279	0.009015917	9.015916706	2.70	492.42
320	0.005163876	0.159076202	1.908914428	0.008821306	8.821305675	2.65	495.06
325	0.005086091	0.156680016	1.880160197	0.008688429	8.688429179	2.61	497.67
330	0.004997218	0.153942226	1.847306714	0.00853661	8.536609583	2.56	500.23
335	0.004872271	0.150093148	1.801117778	0.008323165	8.323165374	2.50	502.73
340	0.004791669	0.147610157	1.771321885	0.008185475	8.185475242	2.46	505.18
345	0.004711067	0.145127166	1.741525992	0.008047785	8.04778511	2.41	507.60
350	0.004586117	0.141278005	1.695336064	0.007834336	7.834336321	2.35	509.95
355	0.004497246	0.138540298	1.662483572	0.007682521	7.682521306	2.30	512.25
360	0.000444422	0.013690686	0.164288229	0.000759194	0.75919416	0.23	512.48



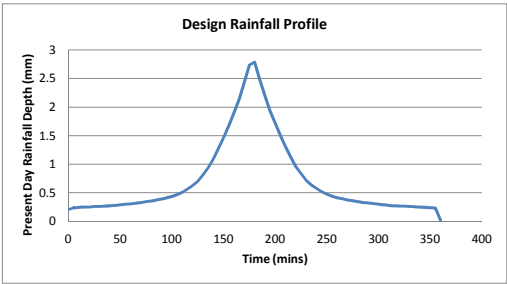
Drainage 2 New pipe in Derry Road, gullies at bus layby to catch runoff. Discharges to new channel.

Catchment Area (DDF3):	26815.00 m²
Volume	1393.94 m³
Flow	0.25 m³/s

Design Rainfall Profile DDF3

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.018702058	18.70205788	5.61	
5	0.004583334	0.238258552	2.859102619	0.021296344	21.29634354	6.39	12.00
10	0.004686111	0.243601298	2.923215574	0.021773896	21.773896	6.53	18.53
15	0.004763887	0.247644386	2.971732627	0.022135281	22.13528066	6.64	25.17
20	0.004861112	0.252698489	3.03238187	0.022587033	22.58703329	6.78	31.95
25	0.004980555	0.258907581	3.106890978	0.023142023	23.14202266	6.94	38.89
30	0.005058334	0.262950809	3.155409703	0.02350342	23.50341977	7.05	45.94
35	0.00514444	0.26742693	3.20912316	0.02390351	23.90351043	7.17	53.11
40	0.005269449	0.273925362	3.287104342	0.024484362	24.48436192	7.35	60.46
45	0.005352775	0.278256953	3.339083434	0.024871534	24.87153397	7.46	67.92
50	0.005544445	0.28822063	3.458647556	0.025762121	25.76212061	7.73	75.65
55	0.005747224	0.29876187	3.585142445	0.026704332	26.70433185	8.01	83.66
60	0.005927781	0.308147844	3.697774126	0.027543281	27.54328144	8.26	91.92
65	0.00613055	0.318688527	3.824262326	0.028485443	28.48544285	8.55	100.47
70	0.006319447	0.328508092	3.9420971	0.029363148	29.36314826	8.81	109.28
75	0.006616663	0.343958488	4.127501851	0.030744156	30.74415615	9.22	118.50
80	0.006897222	0.358542956	4.302515466	0.032047765	32.04776451	9.61	128.11
85	0.007169442	0.372693972	4.47232766	0.03331263	33.3126295	9.99	138.11
90	0.007522224	0.391032885	4.692394616	0.034951823	34.95182268	10.49	148.59
95	0.007905558	0.41095996	4.931519514	0.036732971	36.73297105	11.02	159.61
100	0.008388888	0.43608525	5.233023002	0.038978753	38.97875328	11.69	171.31
105	0.009038889	0.469874698	5.638496382	0.041998967	41.9989668	12.60	183.91
110	0.009766669	0.507707374	6.092488487	0.045380577	45.38057744	13.61	197.52
115	0.010833329	0.56315631	6.757875725	0.050336788	50.33678821	15.10	212.62
120	0.012074993	0.627702578	7.532430932	0.056106149	56.10614873	16.83	229.45
125	0.01347777	0.700624081	8.407488974	0.062624116	62.62411579	18.79	248.24
130	0.01565556	0.813833604	9.76603025	0.07274316	72.74316032	21.82	270.06
135	0.018058345	0.938739217	11.26487061	0.08390764	83.90764038	25.17	295.24
140	0.020961119	1.089636049	13.07563259	0.097395302	97.39530219	29.22	324.46
145	0.024561118	1.276777255	15.32132706	0.114122607	114.122607	34.24	358.69
150	0.028000015	1.455543783	17.46652539	0.130101355	130.1013551	39.03	397.72
155	0.032116631	1.669540602	20.03448723	0.149229104	149.2291042	44.77	442.49
160	0.036388911	1.891629451	22.69955341	0.169080146	169.0801457	50.72	493.22
165	0.041183274	2.140858096	25.69029715	0.191357033	191.3570328	57.41	550.62
170	0.04689447	2.437747064	29.25296477	0.217893958	217.8939584	65.37	615.99
175	0.052650006	2.736940993	32.84329191	0.244636909	244.6369091	73.39	689.38
180	0.053594459	2.786037143	33.43244571	0.249025287	249.0252866	74.71	764.09
185	0.047805573	2.485109547	29.82131456	0.222127375	222.127375	66.64	830.73
190	0.042461136	2.207286045	26.48743255	0.197294584	197.2945844	59.19	889.92
195	0.037199995	1.933792602	23.20551123	0.172848829	172.8488288	51.85	941.77
200	0.032949952	1.712859718	20.55431662	0.153101111	153.1011111	45.93	987.70
205	0.028888919	1.501752252	18.02102702	0.134231622	134.2316221	40.27	1027.97
210	0.025061063	1.302766244	15.63319493	0.116445589	116.4455894	34.93	1062.90
215	0.021772251	1.131801709	13.58162051	0.101164209	101.1642095	30.35	1093.25
220	0.018552775	0.964441515	11.57329817	0.086204997	86.20499738	25.86	1119.11
225	0.016108339	0.837377033	10.0484488	0.074846987	74.84698735	22.45	1141.57
230	0.013913924	0.723296955	8.679563455	0.064650693	64.65069279	19.40	1160.96
235	0.012269456	0.637811482	7.65373778	0.057009716	57.00971627	17.10	1178.07
240	0.011099976	0.577017569	6.924210827	0.051575754	51.5757537	15.47	1193.54
245	0.009944458	0.516949514	6.203394165	0.046206671	46.2066707	13.86	1207.40
250	0.00916666	0.476516685	5.718200221	0.04259265	42.5926497	12.78	1220.18
255	0.008530533	0.443448495	5.32138194	0.039636905	39.63690464	11.89	1232.07
260	0.007969432	0.414280395	4.971364744	0.037029763	37.02976267	11.11	1243.18
265	0.007605556	0.395364754	4.744377054	0.035339902	35.33901964	10.60	1253.78
270	0.007225016	0.375582907	4.506994883	0.033570852	33.57085216	10.07	1263.85
275	0.006955584	0.361576839	4.338922071	0.032318943	32.31894315	9.70	1273.55
280	0.00668609	0.347567566	4.170810792	0.031066748	31.06674761	9.32	1282.87
285	0.006358347	0.330530263	3.966363152	0.029543897	29.54389665	8.86	1291.73
290	0.006169396	0.320707911	3.848494929	0.028665942	28.66594209	8.60	1300.33
295	0.005972236	0.310458797	3.725050563	0.027749842	27.74984213	8.32	1308.66
300	0.005775014	0.300206477	3.602477729	0.026833456	26.83345564	8.05	1316.71
305	0.005591637	0.290673883	3.488086597	0.025981401	25.98140059	7.79	1324.50
310	0.005388903	0.280135012	3.36162014	0.025039401	25.03940112	7.51	1332.01
315	0.005277798	0.274359371	3.292312453	0.024523155	24.52315512	7.36	1339.37
320	0.005163876	0.268437249	3.221246988	0.023993816	23.9938161	7.20	1346.57
325	0.005086091	0.264393743	3.172724917	0.023632394	23.63239407	7.09	1353.66
330	0.004997218	0.259773788	3.117285458	0.023219447	23.2194471	6.97	1360.62
335	0.004872271	0.253278562	3.039342743	0.022638882	22.63888213	6.79	1367.41
340	0.004791669	0.249088574	2.989062893	0.022264367	22.26436708	6.68	1374.09
345	0.004711067	0.244898587	2.938783044	0.021889852	21.88985203	6.57	1380.66
350	0.004586117	0.238403221	2.860838656	0.021309275	21.3092746	6.39	1387.05
355	0.004497246	0.233783406	2.80540087	0.02089634	20.89634009	6.27	1393.32
360	0.000444422	0.023102701	0.277232418	0.002064996	2.064996467	0.62	1393.94



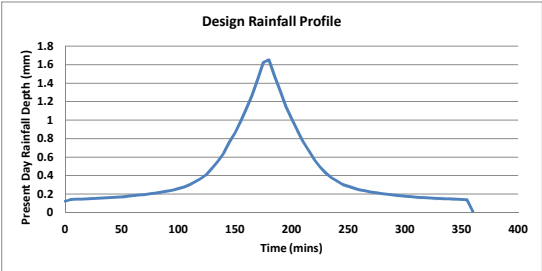
Drainage 2 New pipe in Derry Road, gullies at bus layby to catch runoff. Discharges to new channel.

Catchment Area (DDF4):	109249.00 m ²
Volume	3365.48 m ³
Flow	0.60 m ³ /s

Design Rainfall Profile DDF4

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.045153508	45.15350847	13.55	
5	0.004583334	0.141192274	1.694307286	0.051417049	51.41704909	15.43	28.97
10	0.004686111	0.144358391	1.732300692	0.052570033	52.57003287	15.77	44.74
15	0.004763887	0.146754329	1.76105195	0.053442546	53.44254569	16.03	60.77
20	0.004861112	0.149749396	1.796992757	0.054533239	54.53323935	16.36	77.13
25	0.004980555	0.153428911	1.841146934	0.055873184	55.87318372	16.76	93.90
30	0.005058334	0.155824932	1.869899183	0.056745727	56.74572662	17.02	110.92
35	0.00514444	0.158477486	1.901729835	0.05771169	57.71168965	17.31	128.23
40	0.005269449	0.162328464	1.947941567	0.059114075	59.11407453	17.73	145.97
45	0.005352775	0.164895369	1.978744433	0.060048847	60.04884739	18.01	163.98
50	0.005544445	0.170799855	2.04959826	0.062199045	62.19904454	18.66	182.64
55	0.005747224	0.177046606	2.124559268	0.064473882	64.47388208	19.34	201.98
60	0.005927781	0.182608744	2.191304923	0.066499409	66.49940875	19.95	221.93
65	0.00613055	0.188855164	2.266261966	0.068774126	68.77412598	20.63	242.57
70	0.006319447	0.194674248	2.33609098	0.070893223	70.89322319	21.27	263.83
75	0.006616663	0.20383017	2.445962035	0.074227474	74.22747398	22.27	286.10
80	0.006897222	0.212472941	2.549675291	0.077374854	77.37485442	23.21	309.32
85	0.007169442	0.220858848	2.65030618	0.080428694	80.42869441	24.13	333.44
90	0.007522224	0.231726508	2.780718095	0.084386298	84.38629755	25.32	358.76
95	0.007905558	0.243535314	2.922423766	0.088686632	88.68663169	26.61	385.37
100	0.008388888	0.258424588	3.101095058	0.094108759	94.10875943	28.23	413.60
105	0.009038889	0.278448252	3.341379018	0.101400643	101.4006434	30.42	444.02
110	0.009766669	0.300867936	3.610415228	0.10956507	109.5650703	32.87	476.89
115	0.010833329	0.333727035	4.004724421	0.12153115	121.5311495	36.46	513.35
120	0.012074993	0.371977222	4.463726669	0.135460465	135.4604652	40.64	553.99
125	0.01347777	0.415190584	4.982287006	0.151197187	151.197187	45.36	599.35
130	0.01565556	0.482278669	5.787344026	0.175628208	175.6282077	52.69	652.03
135	0.018058345	0.55629787	6.675574435	0.202583287	202.5832865	60.77	712.81
140	0.020961119	0.645719494	7.748633932	0.235147363	235.1473635	70.54	783.35
145	0.024561118	0.756619574	9.079434891	0.275533106	275.5331062	82.66	866.01
150	0.028000015	0.862556811	10.35068173	0.314111563	314.1115633	94.23	960.25
155	0.032116631	0.989371556	11.87245867	0.360292844	360.2928437	108.09	1068.33
160	0.036388911	1.120981646	13.45177976	0.408220413	408.220413	122.47	1190.80
165	0.041183274	1.268674809	15.22409771	0.462004848	462.0048475	138.60	1329.40
170	0.04689447	1.444611531	17.33533838	0.526074551	526.0745506	157.82	1487.22
175	0.052650006	1.621914175	19.4629701	0.590641672	590.6416724	177.19	1664.42
180	0.053594459	1.651008606	19.81210328	0.601236797	601.2367975	180.37	1844.79
185	0.047805573	1.472678589	17.67214307	0.536295544	536.295544	160.89	2005.68
190	0.042461136	1.308040084	15.69648101	0.476340237	476.3402371	142.90	2148.58
195	0.037199995	1.145967575	13.7516109	0.417319372	417.3193721	125.20	2273.77
200	0.032949952	1.015042511	12.18051013	0.369641264	369.6412641	110.89	2384.67
205	0.028888919	0.889939999	10.67927999	0.324083517	324.0835165	97.23	2481.89
210	0.025061063	0.772020677	9.264248123	0.281141623	281.1416231	84.34	2566.23
215	0.021772251	0.67070691	8.048482919	0.244246864	244.246864	73.27	2639.51
220	0.018552775	0.571529079	6.858348942	0.208129934	208.1299343	62.44	2701.95
225	0.016108339	0.496226797	5.954721561	0.180707604	180.7076044	54.21	2756.16
230	0.013913924	0.428626553	5.143518636	0.156090074	156.0900743	46.83	2802.99
235	0.012269456	0.37796777	4.535613238	0.137642003	137.642003	41.29	2844.28
240	0.011099976	0.341941232	4.103294781	0.124522459	124.5224588	37.36	2881.64
245	0.009944458	0.306344838	3.676138052	0.111559557	111.5595572	33.47	2915.10
250	0.00916666	0.2823843	3.388611599	0.102834008	102.8340079	30.85	2945.95
255	0.008530533	0.262788055	3.153456659	0.095697774	95.69777404	28.71	2974.66
260	0.007969432	0.245503008	2.946036092	0.089403194	89.40319363	26.82	3001.48
265	0.007605556	0.234293579	2.811522943	0.085321131	85.32113056	25.60	3027.08
270	0.007225016	0.222570834	2.670850014	0.081052137	81.05213698	24.32	3051.40
275	0.006955584	0.214270824	2.571249885	0.078029577	78.0295774	23.41	3074.80
280	0.00668609	0.205968913	2.47162696	0.075006326	75.00632604	22.50	3097.31
285	0.006358347	0.195872589	2.350471069	0.071329615	71.32961495	21.40	3118.71
290	0.006169396	0.190051853	2.280622233	0.069209916	69.2099162	20.76	3139.47
295	0.005972236	0.183978217	2.207738602	0.066998121	66.99812071	20.10	3159.57
300	0.005775014	0.177902681	2.134832176	0.064785633	64.78563344	19.44	3179.00
305	0.005591637	0.172253656	2.067043868	0.062728465	62.72846543	18.82	3197.82
310	0.005388903	0.166008309	1.992099709	0.060454139	60.4541392	18.14	3215.96
315	0.005277798	0.162585658	1.9510279	0.059207735	59.20773528	17.76	3233.72
320	0.005163876	0.159076202	1.908914428	0.05792972	57.92972011	17.38	3251.10
325	0.005086091	0.156680016	1.880160197	0.057057117	57.05711706	17.12	3268.22
330	0.004997218	0.153942226	1.847306714	0.056060114	56.06011423	16.82	3285.03
335	0.004872271	0.150093148	1.801117778	0.054658421	54.65842113	16.40	3301.43
340	0.004791669	0.147610157	1.771321885	0.053754207	53.75420682	16.13	3317.56
345	0.004711067	0.145127166	1.741525992	0.052849993	52.84999251	15.85	3333.41
350	0.004586117	0.141278005	1.695336064	0.051448269	51.44826934	15.43	3348.85
355	0.004497246	0.138540298	1.662483572	0.050451297	50.45129659	15.14	3363.98
360	0.004444422	0.013690686	0.164288229	0.004985646	4.985645754	1.50	3365.48

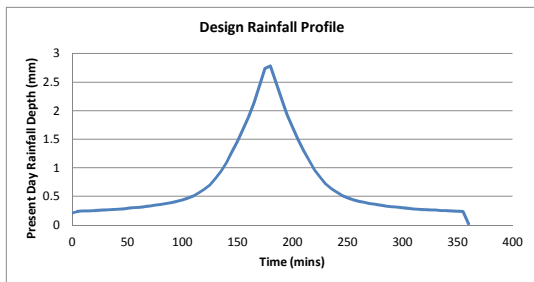


Drainage 3 New pipe in Castle Road (North), new gullies at upstream extent. Discharges to D8.

Catchment Area (DDF3):	5356.00 m²
Volume	278.42 m³
Flow	0.05 m³/s

Design Rainfall Profile DDF3
100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.003735529	3.735529443	1.12	
5	0.004583334	0.238258552	2.859102619	0.004253709	4.253709341	1.28	2.40
10	0.004686111	0.243601298	2.923215574	0.004349095	4.349095171	1.30	3.70
15	0.004763887	0.247644386	2.971732627	0.004421278	4.421277764	1.33	5.03
20	0.004861112	0.252698489	3.03238187	0.00451151	4.51151036	1.35	6.38
25	0.004980555	0.258907581	3.106890978	0.004622363	4.622363355	1.39	7.77
30	0.005058334	0.262950809	3.155409703	0.004694548	4.694548436	1.41	9.18
35	0.00514444	0.26742693	3.20912316	0.004774462	4.774462124	1.43	10.61
40	0.005269449	0.273925362	3.287104342	0.004890481	4.890480793	1.47	12.08
45	0.005352775	0.278256953	3.339083434	0.004967814	4.967814132	1.49	13.57
50	0.005544445	0.28822063	3.458647556	0.005145699	5.145698974	1.54	15.11
55	0.005747224	0.29876187	3.585142445	0.005333895	5.333895261	1.60	16.71
60	0.005927781	0.308147844	3.697774126	0.005501466	5.501466171	1.65	18.36
65	0.00613055	0.318688527	3.824262326	0.005689653	5.689652505	1.71	20.07
70	0.006319447	0.328508092	3.9420971	0.005864964	5.864964463	1.76	21.83
75	0.006616663	0.343958488	4.127501851	0.006140806	6.140805531	1.84	23.67
80	0.006897222	0.358542956	4.302515466	0.006401187	6.401186899	1.92	25.59
85	0.007169442	0.372693972	4.47232766	0.00665383	6.653829707	2.00	27.59
90	0.007522224	0.391032885	4.692394616	0.00698124	6.981240435	2.09	29.68
95	0.007905558	0.41095996	4.931519514	0.007337005	7.337005144	2.20	31.88
100	0.008388888	0.43608525	5.233023002	0.007785575	7.785575333	2.34	34.22
105	0.009038889	0.469874698	5.638496382	0.00838883	8.388829617	2.52	36.73
110	0.009766669	0.507707374	6.092488487	0.009064269	9.064268982	2.72	39.45
115	0.010833329	0.56315631	6.757875725	0.010054217	10.05421733	3.02	42.47
120	0.012074993	0.627702578	7.532430932	0.011206583	11.20658335	3.36	45.83
125	0.01347777	0.700624081	8.407488974	0.012508475	12.50847526	3.75	49.58
130	0.01565556	0.813833604	9.76600325	0.014529643	14.52964261	4.36	53.94
135	0.018058345	0.938739217	11.26487061	0.016759624	16.75962416	5.03	58.97
140	0.020961119	1.089636049	13.07563259	0.019453636	19.45363656	5.84	64.81
145	0.024561118	1.276777251	15.32132706	0.02279473	22.79472993	6.84	71.64
150	0.028000015	1.455543783	17.46652539	0.025986308	25.98630833	7.80	79.44
155	0.032116631	1.669540602	20.03448723	0.029806865	29.80686488	8.94	88.38
160	0.036388911	1.891629451	22.69955341	0.033771891	33.77189113	10.13	98.51
165	0.041183274	2.140858096	25.69029715	0.038221453	38.2214532	11.47	109.98
170	0.04689447	2.437747064	29.25296477	0.043521911	43.52191092	13.06	123.04
175	0.052650006	2.736940993	32.84329191	0.04886352	48.86351986	14.66	137.70
180	0.053594459	2.786037143	33.43244571	0.04974005	49.74004979	14.92	152.62
185	0.047805573	2.485109547	29.82131456	0.044367489	44.3674891	13.31	165.93
190	0.042461136	2.207286045	26.48743255	0.039407414	39.40741353	11.82	177.75
195	0.037199995	1.933792602	23.20551123	0.034524644	34.52464393	10.36	188.11
200	0.032949952	1.712859718	20.55431662	0.030580255	30.5802555	9.17	197.28
205	0.028888919	1.501752252	18.02102702	0.026811284	26.81128353	8.04	205.33
210	0.025061063	1.302766244	15.63319493	0.02325872	23.25872001	6.98	212.30
215	0.021772251	1.131801709	13.58162051	0.020206433	20.20643318	6.06	218.37
220	0.018552775	0.964441515	11.57329817	0.017218496	17.21849584	5.17	223.53
225	0.016108339	0.837370733	10.0484488	0.014949859	14.94985882	4.48	228.02
230	0.013913924	0.723296955	8.679563455	0.012913262	12.91326163	3.87	231.89
235	0.012269456	0.637811482	7.65373778	0.011387061	11.38706099	3.42	235.31
240	0.011099976	0.577017569	6.924210827	0.010301687	10.301687	3.09	238.40
245	0.009944458	0.516949514	6.203394165	0.009229272	9.229271985	2.77	241.17
250	0.00916666	0.476516685	5.718200221	0.008507411	8.507411218	2.55	243.72
255	0.008530533	0.443448495	5.32138194	0.007917034	7.917033797	2.38	246.09
260	0.007969432	0.414280395	4.971364744	0.007396286	7.396285991	2.22	248.31
265	0.007605556	0.395364754	4.744377054	0.007058579	7.05857875	2.12	250.43
270	0.007225016	0.375582907	4.506994883	0.006705407	6.705406831	2.01	252.44
275	0.006955584	0.361576839	4.338922071	0.006455352	6.455351837	1.94	254.38
280	0.00668609	0.347567566	4.170810792	0.00620524	6.205239612	1.86	256.24
285	0.006358347	0.330530263	3.966363152	0.005901067	5.901066957	1.77	258.01
290	0.006169396	0.320707911	3.848494929	0.005725705	5.725705233	1.72	259.73
295	0.005972236	0.310458797	3.725505563	0.005542724	5.542724387	1.66	261.39
300	0.005775014	0.300206477	3.602477729	0.005359686	5.359686311	1.61	263.00
305	0.005591637	0.290673883	3.488086597	0.005189498	5.189497727	1.56	264.55
310	0.005388903	0.280135012	3.36162014	0.005001344	5.001343741	1.50	266.05
315	0.005277798	0.274359371	3.292312453	0.004898229	4.898229306	1.47	267.52
320	0.005163876	0.268437249	3.221246988	0.0047925	4.792499685	1.44	268.96
325	0.005086091	0.264393743	3.172724917	0.00472031	4.720309627	1.42	270.38
330	0.004997218	0.259773788	3.117285458	0.004637828	4.637828032	1.39	271.77
335	0.004872271	0.253278562	3.039342743	0.004521867	4.521866592	1.36	273.13
340	0.004791669	0.249088574	2.989062893	0.004447061	4.447061349	1.33	274.46
345	0.004711067	0.244898587	2.938783044	0.004372256	4.372256106	1.31	275.77
350	0.004586117	0.238403221	2.860838656	0.004256292	4.256292179	1.28	277.05
355	0.004497246	0.233783406	2.80540087	0.004173813	4.173813072	1.25	278.30
360	0.000444422	0.023102701	0.277232418	0.00041246	0.41246023	0.12	278.42



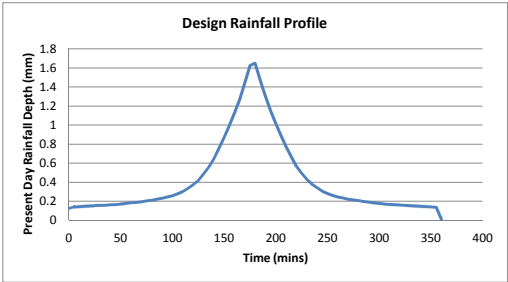
Drainage 3 New pipe in Castle Road (North), new gullies at upstream extent. Discharges to D8.

Catchment Area (DDF4):	63369.00 m ²
Volume	1952.12 m ³
Flow	0.35 m ³ /s

Design Rainfall Profile DDF4

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.026190928	26.19092786	7.86	
5	0.004583334	0.141192274	1.694307286	0.029824044	29.82404401	8.95	16.80
10	0.004686111	0.144358391	1.732300692	0.030492823	30.49282294	9.15	25.95
15	0.004763887	0.146754329	1.76105195	0.030998917	30.99891695	9.30	35.25
20	0.004861112	0.149749396	1.796992757	0.031631565	31.631565	9.49	44.74
25	0.004980555	0.153428911	1.841146934	0.032408789	32.4087889	9.72	54.46
30	0.005058334	0.155824932	1.869899183	0.0329149	32.91490037	9.87	64.34
35	0.00514444	0.158477486	1.901729835	0.033475199	33.47519942	10.04	74.38
40	0.005269449	0.162328464	1.947941567	0.034288641	34.28864144	10.29	84.67
45	0.005352775	0.164895369	1.978744433	0.034830849	34.83084889	10.45	95.12
50	0.005544445	0.170799855	2.04959826	0.036078053	36.07805338	10.82	105.94
55	0.005747224	0.177046606	2.124559268	0.037397555	37.39755452	11.22	117.16
60	0.005927781	0.182608744	2.191304923	0.038572445	38.5724449	11.57	128.73
65	0.00613055	0.188855164	2.266261966	0.039891876	39.89187626	11.97	140.70
70	0.006319447	0.194674248	2.33609098	0.041121041	41.12104148	12.34	153.04
75	0.006616663	0.20383017	2.445962035	0.043055047	43.05504672	12.92	165.95
80	0.006897222	0.212472941	2.549675291	0.044880659	44.88065932	13.46	179.42
85	0.007169442	0.220858848	2.65030618	0.046652015	46.65201453	14.00	193.41
90	0.007522224	0.231726508	2.780718095	0.04849759	48.94759027	14.68	208.10
95	0.007905558	0.243535314	2.922423766	0.051441964	51.44196435	15.43	223.53
100	0.008388888	0.258442588	3.101095058	0.05487026	54.58702575	16.38	239.90
105	0.009038889	0.278448252	3.341379018	0.058816624	58.81662417	17.64	257.55
110	0.009766669	0.300867936	3.610415228	0.063552334	63.55233405	19.07	276.62
115	0.010833329	0.333727035	4.004724421	0.070493162	70.49316162	21.15	297.76
120	0.012074993	0.371977222	4.463726669	0.078572749	78.5727487	23.57	321.34
125	0.01347777	0.415190584	4.982287006	0.087700707	87.70070702	26.31	347.65
130	0.01565556	0.482278669	5.787344026	0.101871723	101.8717232	30.56	378.21
135	0.018058345	0.55629787	6.675574435	0.117506799	117.506799	35.25	413.46
140	0.020961119	0.645719494	7.748633932	0.136395329	136.3953288	40.92	454.38
145	0.024561118	0.756619574	9.079434891	0.159820753	159.8207527	47.95	502.32
150	0.028000015	0.862556811	10.35068173	0.182197875	182.1978751	54.66	556.98
155	0.032116631	0.989371556	11.87245867	0.208984954	208.9849538	62.70	619.68
160	0.036388911	1.120981646	13.45177976	0.236784953	236.7849532	71.04	690.71
165	0.041183274	1.268674809	15.22409771	0.26798218	267.98218	80.39	771.11
170	0.04689447	1.444611531	17.33533838	0.305145294	305.1452938	91.54	862.65
175	0.052650006	1.621914175	19.4629701	0.342596931	342.5969312	102.78	965.43
180	0.053594459	1.651008606	19.81210328	0.348742548	348.7425479	104.62	1070.05
185	0.047805573	1.472678589	17.67214307	0.311073898	311.0738984	93.32	1163.38
190	0.042461136	1.308040084	15.69648101	0.276297307	276.2973069	82.89	1246.27
195	0.037199995	1.145967575	13.7516109	0.242062731	242.0627309	72.62	1318.88
200	0.032949952	1.015042511	12.18051013	0.21440743	214.4074295	64.32	1383.21
205	0.028888919	0.889939999	10.67927999	0.187982026	187.982026	56.39	1439.60
210	0.025061063	0.772020677	9.264248123	0.163073928	163.0739276	48.92	1488.52
215	0.021772251	0.67070691	8.048482919	0.141673421	141.6734206	42.50	1531.03
220	0.018552775	0.571529079	6.858348942	0.120724087	120.7240873	36.22	1567.24
225	0.016108339	0.496226797	5.954721561	0.104817986	104.8179863	31.45	1598.69
230	0.013913924	0.428626553	5.143518636	0.090538787	90.53878678	27.16	1625.85
235	0.012269456	0.37796777	4.535613238	0.079838132	79.83813202	23.95	1649.80
240	0.011099976	0.341941232	4.103294781	0.072228246	72.22824639	21.67	1671.47
245	0.009944458	0.306344838	3.676138052	0.06470922	64.70922006	19.41	1690.88
250	0.00916666	0.2823843	3.388611599	0.059648036	59.64803568	17.89	1708.78
255	0.008530533	0.262788055	3.153456659	0.055508721	55.50872084	16.65	1725.43
260	0.007969432	0.245503008	2.946036092	0.0518576	51.85760032	15.56	1740.99
265	0.007605556	0.234293579	2.811522943	0.049489833	49.48983261	14.85	1755.83
270	0.007225016	0.222570834	2.670850014	0.047013637	47.01363737	14.10	1769.94
275	0.006955584	0.214270824	2.571249885	0.045260426	45.26042609	13.58	1783.52
280	0.00668609	0.205968913	2.47162696	0.043506814	43.50681356	13.05	1796.57
285	0.006358347	0.195872589	2.350471069	0.041374167	41.37416699	12.41	1808.98
290	0.006169396	0.190051853	2.280622233	0.040144653	40.14465285	12.04	1821.02
295	0.005972236	0.183978217	2.207738602	0.038861719	38.86171874	11.66	1832.68
300	0.005775014	0.177902681	2.134832176	0.037578383	37.57838338	11.27	1843.96
305	0.005591637	0.172253656	2.067043868	0.03638514	36.38513969	10.92	1854.87
310	0.005388903	0.166008309	1.992099709	0.035065935	35.06593513	10.52	1865.39
315	0.005277798	0.162585658	1.9510279	0.034342969	34.34296861	10.30	1875.69
320	0.005163876	0.159076202	1.908914428	0.033601666	33.60166623	10.08	1885.77
325	0.005086091	0.156680016	1.880160197	0.03309552	33.09551987	9.93	1895.70
330	0.004997218	0.153942226	1.847306714	0.032517216	32.51721644	9.76	1905.46
335	0.004872271	0.150093148	1.801117778	0.031704176	31.70417568	9.51	1914.97
340	0.004791669	0.147610157	1.771321885	0.031179693	31.17969347	9.35	1924.32
345	0.004711067	0.145127166	1.741525992	0.030655211	30.65521127	9.20	1933.52
350	0.004586117	0.141278005	1.695336064	0.029842153	29.84215306	8.95	1942.47
355	0.004497246	0.138540298	1.662483572	0.029263867	29.26386707	8.78	1951.25
360	0.000444422	0.013690686	0.164288229	0.002891884	2.891883549	0.87	1952.12



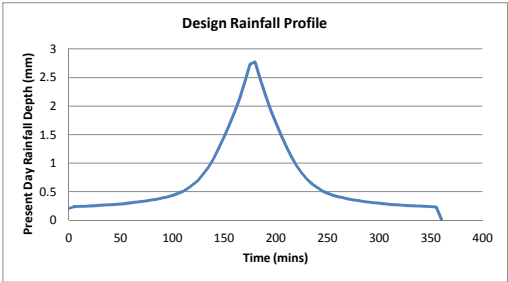
Drainage 3 New pipe in Castle Road (North), new gullies at upstream extent. Discharges to D8.

Catchment Area (DDF6):	2572.00 m²
Volume	133.13 m³
Flow	0.02 m³/s

Design Rainfall Profile DDF6

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.20834639	2.500156678	0.001786223	1.786223049	0.54	
5	0.004583334	0.23724749	2.846969881	0.002034002	2.034001815	0.61	1.15
10	0.004686111	0.242567564	2.91081077	0.002079613	2.079612583	0.62	1.77
15	0.004763887	0.246593495	2.959121938	0.002114128	2.114128229	0.63	2.40
20	0.004861112	0.251626151	3.019513813	0.002157275	2.157274869	0.65	3.05
25	0.004980555	0.257808895	3.093706738	0.002210282	2.210281592	0.66	3.71
30	0.005058334	0.261834964	3.142019572	0.002244798	2.244798427	0.67	4.39
35	0.00514444	0.266292091	3.195505093	0.002283011	2.283010861	0.68	5.07
40	0.005269449	0.272762947	3.273155358	0.002338488	2.338487661	0.70	5.77
45	0.005352775	0.277076156	3.324913875	0.002375466	2.375466246	0.71	6.49
50	0.005544445	0.286997552	3.44397062	0.002460526	2.460525676	0.74	7.23
55	0.005747224	0.29749406	3.569928723	0.002550516	2.550515743	0.77	7.99
60	0.005927781	0.306840204	3.682082445	0.002630643	2.630643347	0.79	8.78
65	0.00613055	0.317336157	3.808033886	0.002720629	2.720628654	0.82	9.60
70	0.006319447	0.327114052	3.925368623	0.002804458	2.804457805	0.84	10.44
75	0.006616663	0.342498883	4.1099866	0.002936357	2.936357093	0.88	11.32
80	0.006897222	0.357021461	4.284257537	0.003060864	3.060863996	0.92	12.24
85	0.007169442	0.371112427	4.453349125	0.003181671	3.181670541	0.95	13.19
90	0.007522224	0.389373518	4.672482216	0.003338229	3.338228961	1.00	14.19
95	0.007905558	0.409216031	4.910592376	0.003508345	3.508345442	1.05	15.24
100	0.008388888	0.434234702	5.21081642	0.003722839	3.722838842	1.12	16.36
105	0.009038889	0.467880763	5.614569154	0.004011298	4.01129774	1.20	17.56
110	0.009766669	0.505552893	6.066634722	0.004334273	4.334273473	1.30	18.87
115	0.010833329	0.560766653	6.729198358	0.004807638	4.807638382	1.44	20.31
120	0.012074993	0.625038892	7.500466703	0.005358667	5.358666766	1.61	21.92
125	0.01347777	0.697650949	8.371811394	0.005981194	5.98119414	1.79	23.71
130	0.01565556	0.810380062	9.72456075	0.006947658	6.947658402	2.08	25.79
135	0.018058345	0.934755633	11.21706759	0.008013972	8.013971625	2.40	28.20
140	0.020961119	1.085012127	13.02014552	0.009302171	9.302170633	2.79	30.99
145	0.024561118	1.27135919	15.25631028	0.010899786	10.89978612	3.27	34.26
150	0.028000015	1.449367113	17.39240536	0.012425907	12.42590738	3.73	37.99
155	0.032116631	1.662455827	19.94946992	0.014252788	14.25278796	4.28	42.26
160	0.036388911	1.883602231	22.60322677	0.01614875	16.1487498	4.84	47.11
165	0.041183274	2.131773262	25.58127915	0.018276403	18.27640277	5.48	52.59
170	0.04689447	2.427402368	29.12882842	0.02081093	20.81092964	6.24	58.83
175	0.052650006	2.725326653	32.70391984	0.023365134	23.36513384	7.01	65.84
180	0.053594459	2.774214462	33.29057354	0.023784265	23.78426532	7.14	72.98
185	0.047805573	2.474563866	29.69476639	0.021215261	21.21526088	6.36	79.34
190	0.042461136	2.197919322	26.37503186	0.018843495	18.84349499	5.65	85.00
195	0.037199995	1.925586461	23.10703754	0.016508695	16.50869459	4.95	89.95
200	0.032949952	1.705591116	20.46709339	0.014622601	14.62260117	4.39	94.33
205	0.028888919	1.495379495	17.94455393	0.012820387	12.82038687	3.85	98.18
210	0.025061063	1.297237893	15.56685472	0.011121653	11.12165287	3.34	101.52
215	0.021772251	1.126998855	13.52398626	0.009662137	9.662136849	2.90	104.42
220	0.018552775	0.960348861	11.52418633	0.008233391	8.233390902	2.47	106.89
225	0.016108339	0.83381731	10.00580773	0.007148594	7.148593742	2.14	109.03
230	0.013913924	0.720227609	8.642731314	0.006174751	6.174751372	1.85	110.88
235	0.012269456	0.635104898	7.62125878	0.005444966	5.444965995	1.63	112.52
240	0.011099976	0.574568967	6.894827609	0.004925971	4.925971281	1.48	113.99
245	0.009944458	0.514755814	6.177069766	0.004413173	4.413173177	1.32	115.32
250	0.00916666	0.474494564	5.693934766	0.004068	4.068000061	1.22	116.54
255	0.008530533	0.4415667	5.298800402	0.003785699	3.785698509	1.14	117.67
260	0.007969432	0.412522377	4.950268521	0.003536692	3.536691843	1.06	118.74
265	0.007605556	0.393687005	4.724244064	0.00337521	3.375209925	1.01	119.75
270	0.007225016	0.373989103	4.487869236	0.003206333	3.206333243	0.96	120.71
275	0.006955584	0.360042471	4.320509649	0.003086764	3.086764116	0.93	121.64
280	0.00668609	0.346092647	4.153111758	0.002967168	2.967167623	0.89	122.53
285	0.006358347	0.329127642	3.949531702	0.002821721	2.821720982	0.85	123.37
290	0.006169396	0.319346971	3.832163657	0.002737868	2.737868035	0.82	124.19
295	0.005972236	0.30914135	3.709696202	0.002650372	2.650371842	0.80	124.99
300	0.005775014	0.298932537	3.587190444	0.002562848	2.562848284	0.77	125.76
305	0.005591637	0.289440395	3.473284736	0.002481469	2.481468983	0.74	126.50
310	0.005388903	0.278946245	3.347354945	0.002391499	2.391499144	0.72	127.22
315	0.005277798	0.273195114	3.278341369	0.002342193	2.342192778	0.70	127.92
320	0.005163876	0.267298123	3.207577473	0.002291636	2.291635905	0.69	128.61
325	0.005086091	0.263271776	3.159261308	0.002257117	2.25711669	0.68	129.29
330	0.004997218	0.258671426	3.104057109	0.002217676	2.217676357	0.67	129.95
335	0.004872271	0.252203762	3.026445148	0.002162227	2.162226922	0.65	130.60
340	0.004791669	0.248031555	2.976378663	0.002126457	2.1264572	0.64	131.24
345	0.004711067	0.243859348	2.926312178	0.002090687	2.090687478	0.63	131.87
350	0.004586117	0.237391546	2.848698551	0.002035237	2.035236854	0.61	132.48
355	0.004497246	0.232791335	2.793496017	0.001995798	1.99579771	0.60	133.08
360	0.000444422	0.023004664	0.276055969	0.000197227	0.197226653	0.06	133.13



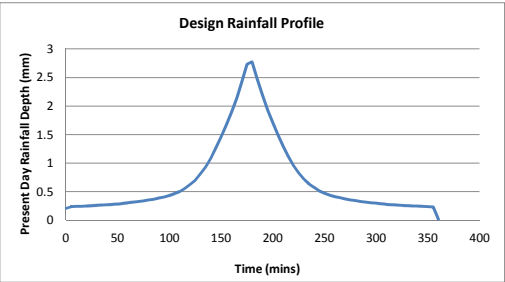
Drainage 4 New pipe through the Diamond, new gullies in Diamond and Irish Row. Discharges to D8.

Catchment Area (DDF6):	1047.00 m ²
Volume	54.20 m ³
Flow	0.01 m ³ /s

Design Rainfall Profile DDF6

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.20834639	2.500156678	0.000727129	0.7271289	0.22	
5	0.004583334	0.23724749	2.846969881	0.000827994	0.82799374	0.25	0.47
10	0.004686111	0.242567564	2.91081077	0.000846561	0.846560799	0.25	0.72
15	0.004763887	0.246593495	2.959121938	0.000860611	0.860611297	0.26	0.98
20	0.004861112	0.251626151	3.019513813	0.000878175	0.878175267	0.26	1.24
25	0.004980555	0.257808895	3.093706738	0.000899753	0.899753043	0.27	1.51
30	0.005058334	0.261834964	3.142019572	0.000913804	0.913804025	0.27	1.79
35	0.00514444	0.266292091	3.195505093	0.000929359	0.929359398	0.28	2.07
40	0.005269449	0.272762947	3.273155358	0.000951943	0.951942683	0.29	2.35
45	0.005352775	0.277076156	3.324913875	0.000966996	0.966995785	0.29	2.64
50	0.005544445	0.286997552	3.44397062	0.001001621	1.001621455	0.30	2.94
55	0.005747224	0.29749406	3.569928723	0.001038254	1.03825427	0.31	3.25
60	0.005927781	0.306840204	3.682082445	0.001070872	1.070872311	0.32	3.57
65	0.00613055	0.317336157	3.808033886	0.001107503	1.107503189	0.33	3.91
70	0.006319447	0.327114052	3.925368623	0.001141628	1.141628041	0.34	4.25
75	0.006616663	0.342498883	4.1099866	0.001195321	1.195321103	0.36	4.61
80	0.006897222	0.357021461	4.284257537	0.001246005	1.2460049	0.37	4.98
85	0.007169442	0.371112427	4.453349125	0.001295182	1.29518237	0.39	5.37
90	0.007522224	0.389373518	4.672482216	0.001358914	1.358913578	0.41	5.78
95	0.007905558	0.409216031	4.910592376	0.001428164	1.428163949	0.43	6.21
100	0.008388888	0.434234702	5.21081642	0.001515479	1.515479109	0.45	6.66
105	0.009038889	0.467880763	5.614569154	0.001632904	1.632903862	0.49	7.15
110	0.009766669	0.505552893	6.066634722	0.00176438	1.764379598	0.53	7.68
115	0.010833329	0.56076653	6.729198358	0.001957075	1.957075189	0.59	8.27
120	0.012074993	0.625038892	7.500466703	0.002181386	2.181385733	0.65	8.92
125	0.01347777	0.697650949	8.371811394	0.002434802	2.434801814	0.73	9.65
130	0.01565556	0.810380062	9.72456075	0.002828226	2.828226418	0.85	10.50
135	0.018058345	0.934755633	11.21706759	0.003262297	3.262297158	0.98	11.48
140	0.020961119	1.085012127	13.02014552	0.003786692	3.786692322	1.14	12.61
145	0.024561118	1.27135919	15.25631028	0.004437044	4.437043574	1.33	13.95
150	0.028000015	1.449367113	17.39240536	0.005058291	5.058291225	1.52	15.46
155	0.032116631	1.662455827	19.94946992	0.005801971	5.801970836	1.74	17.20
160	0.036388911	1.883602231	22.60322677	0.006573772	6.573771787	1.97	19.18
165	0.041183274	2.131773262	25.58127915	0.007439889	7.439888686	2.23	21.41
170	0.04689447	2.427402368	29.12882842	0.008471634	8.471634266	2.54	23.95
175	0.052650006	2.725326653	32.70391984	0.00951139	9.51139002	2.85	26.80
180	0.053594459	2.774214462	33.29057354	0.009682008	9.682008471	2.90	29.71
185	0.047805573	2.474563866	29.69476639	0.008636228	8.636227892	2.59	32.30
190	0.042461136	2.197919322	26.37503186	0.007670738	7.670738434	2.30	34.60
195	0.037199995	1.925586461	23.10703754	0.006720297	6.72029675	2.02	36.62
200	0.032949952	1.705591116	20.46709339	0.005952513	5.952512995	1.79	38.40
205	0.028888919	1.495379495	17.94455393	0.005218874	5.218874436	1.57	39.97
210	0.025061063	1.297237893	15.56685472	0.00452736	4.527360248	1.36	41.33
215	0.021772251	1.126998855	13.52398623	0.003933226	3.933226004	1.18	42.51
220	0.018552775	0.960348861	11.52418633	0.003351618	3.351617525	1.01	43.51
225	0.016108339	0.83381731	10.00580773	0.002910022	2.910022413	0.87	44.38
230	0.013913924	0.720227609	8.642731314	0.002513594	2.513594357	0.75	45.14
235	0.012269456	0.635104898	7.62125878	0.002216516	2.216516095	0.66	45.80
240	0.011099976	0.574568967	6.894827609	0.002005246	2.005245696	0.60	46.40
245	0.009944458	0.514755814	6.177069766	0.001796498	1.79649779	0.54	46.94
250	0.00916666	0.474494564	5.693934766	0.001655986	1.655986028	0.50	47.44
255	0.008530533	0.4415667	5.298800402	0.001541068	1.541067784	0.46	47.90
260	0.007969432	0.412522377	4.950268521	0.001439703	1.439703095	0.43	48.33
265	0.007605556	0.393687005	4.724244064	0.001373968	1.373967649	0.41	48.75
270	0.007225016	0.373989103	4.487869236	0.001305222	1.305221969	0.39	49.14
275	0.006955584	0.360042471	4.320509649	0.001256548	1.256548223	0.38	49.52
280	0.00668609	0.346092647	4.153111758	0.001207863	1.207863336	0.36	49.88
285	0.006358347	0.329127642	3.949531702	0.001148655	1.14865547	0.34	50.22
290	0.006169396	0.319346971	3.832163657	0.001114521	1.11452093	0.33	50.56
295	0.005972236	0.30914135	3.709696202	0.001078903	1.078903312	0.32	50.88
300	0.005775014	0.298932537	3.587190444	0.001043275	1.043274554	0.31	51.19
305	0.005591637	0.289440395	3.473284736	0.001010147	1.010146977	0.30	51.50
310	0.005388903	0.278946245	3.347354945	0.000973522	0.973522396	0.29	51.79
315	0.005277798	0.273195114	3.278341369	0.000953451	0.953450948	0.29	52.07
320	0.005163876	0.267298123	3.207577473	0.00093287	0.932870448	0.28	52.35
325	0.005086091	0.263271776	3.159261308	0.000918818	0.918818497	0.28	52.63
330	0.004997218	0.258671426	3.104057109	0.000902763	0.902763276	0.27	52.90
335	0.004872271	0.252203762	3.026445148	0.000880191	0.88019113	0.26	53.16
340	0.004791669	0.248031555	2.976378663	0.00086563	0.865630128	0.26	53.42
345	0.004711067	0.243859348	2.926312178	0.000851069	0.851069125	0.26	53.68
350	0.004586117	0.237391546	2.848698551	0.000828496	0.828496495	0.25	53.93
355	0.004497246	0.232791335	2.793496017	0.000812442	0.812441758	0.24	54.17
360	0.000444422	0.023004664	0.276055969	8.02863E-05	0.080286278	0.02	54.20



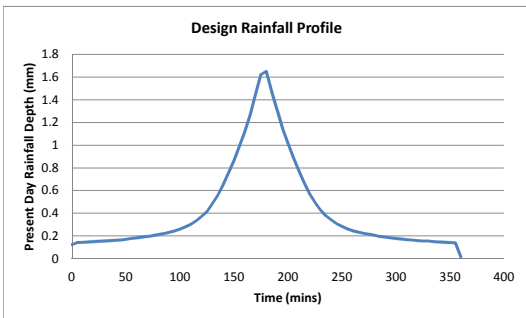
Drainage 4 New pipe through the Diamond, new gullies in Diamond and Irish Row. Discharges to D8.

Catchment Area (DDF4): 78851.00 m²
Volume 2429.05 m³
Flow 0.43 m³/s

Design Rainfall Profile DDF 4

100years 360 Min

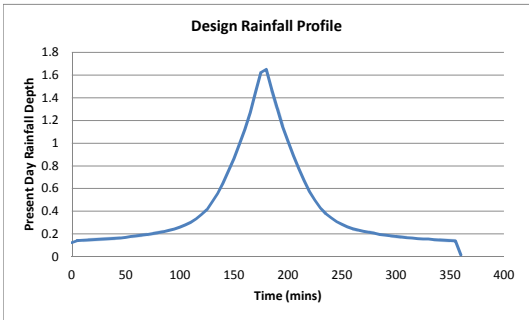
Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.032589766	32.58976555	9.78	
5	0.004583334	0.141192274	1.694307286	0.037110507	37.11050662	11.13	20.91
10	0.004686111	0.144358391	1.732300692	0.037942678	37.9426783	11.38	32.29
15	0.004763887	0.146754329	1.76105195	0.038572419	38.5724187	11.57	43.86
20	0.004861112	0.149749396	1.796992757	0.039359632	39.35963218	11.81	55.67
25	0.004980555	0.153428911	1.841146934	0.040326744	40.32674358	12.10	67.77
30	0.005058334	0.155824932	1.869899183	0.040956506	40.95650568	12.29	80.06
35	0.00514444	0.158477486	1.901729835	0.041653694	41.65369423	12.50	92.55
40	0.005269449	0.162328464	1.947941567	0.042665872	42.66587237	12.80	105.35
45	0.005352775	0.164895369	1.978744433	0.043340549	43.34054925	13.00	118.36
50	0.005544445	0.170799855	2.04959826	0.044892465	44.89246456	13.47	131.82
55	0.005747224	0.177046606	2.124559268	0.04653434	46.53433968	13.96	145.78
60	0.005927781	0.182608744	2.191304923	0.047996273	47.99627346	14.40	160.18
65	0.00613055	0.188855164	2.266261966	0.049638062	49.63806175	14.89	175.07
70	0.006319447	0.194674248	2.33609098	0.051167531	51.16753052	15.35	190.42
75	0.006616663	0.20383017	2.445962035	0.053574042	53.57404233	16.07	206.50
80	0.006897222	0.212472941	2.549675291	0.05584568	55.84567955	16.75	223.25
85	0.007169442	0.220858848	2.65030618	0.058049804	58.0498035	17.41	240.66
90	0.007522224	0.231726508	2.780718095	0.060906223	60.90622292	18.27	258.94
95	0.007905558	0.243535314	2.922423766	0.06401001	64.01001011	19.20	278.14
100	0.008388888	0.258424588	3.101095058	0.067923457	67.92345733	20.38	298.52
105	0.009038889	0.278448252	3.341379018	0.07318641	73.18641027	21.96	320.47
110	0.009766669	0.300867936	3.610415228	0.079079125	79.07912532	23.72	344.20
115	0.010833329	0.333727035	4.004724421	0.087715701	87.71570148	26.31	370.51
120	0.012074993	0.371977222	4.463726669	0.097769253	97.76925322	29.33	399.84
125	0.01347777	0.415190584	4.982287006	0.109127309	109.1273091	32.74	432.58
130	0.01565556	0.482278669	5.787344026	0.126760518	126.7605177	38.03	470.61
135	0.018058345	0.55629787	6.675574435	0.146215478	146.2154777	43.86	514.47
140	0.020961119	0.645719494	7.748633932	0.169718759	169.7187595	50.92	565.39
145	0.024561118	0.756619574	9.079434891	0.198867367	198.8673668	59.66	625.05
150	0.028000015	0.862556811	10.35068173	0.226711557	226.7115569	68.01	693.06
155	0.032116631	0.989371556	11.87245867	0.260043122	260.0431219	78.01	771.08
160	0.036388911	1.120981646	13.45177976	0.294635079	294.6350794	88.39	859.47
165	0.041183274	1.268674809	15.22409771	0.333454258	333.454258	100.04	959.50
170	0.04689447	1.444611531	17.33533838	0.379696888	379.6968795	113.91	1073.41
175	0.052650006	1.621914175	19.4629701	0.426298515	426.2985154	127.89	1201.30
180	0.053594459	1.651008606	19.81210328	0.433945599	433.9455988	130.18	1331.48
185	0.047805573	1.472768589	17.67214307	0.387073931	387.0739315	116.12	1447.61
190	0.042461136	1.308040084	15.69648101	0.343800896	343.8008955	103.14	1550.75
195	0.037199995	1.145967575	13.7516109	0.301202298	301.2022976	90.36	1641.11
200	0.032949952	1.015042511	12.18051013	0.26679039	266.79039	80.04	1721.14
205	0.028888919	0.889399999	10.67927999	0.233908863	233.9088629	70.17	1791.32
210	0.025061063	0.772020677	9.264248123	0.202915341	202.9153413	60.87	1852.19
215	0.021772251	0.67070691	8.048482919	0.176286369	176.2863685	52.89	1905.08
220	0.018552775	0.571529079	6.858348942	0.150218798	150.2187979	45.07	1950.14
225	0.016108339	0.496226797	5.954721561	0.130426597	130.4265972	39.13	1989.27
230	0.013913924	0.428626553	5.143518636	0.112658774	112.6587744	33.80	2023.07
235	0.012269456	0.37796777	4.535613238	0.099343789	99.34378873	29.80	2052.87
240	0.011099976	0.341941232	4.103294781	0.089874694	89.87469356	26.96	2079.83
245	0.009944458	0.306344838	3.676138052	0.080518656	80.51865598	24.16	2103.99
250	0.00916666	0.2823843	3.388611599	0.074220948	74.22094811	22.27	2126.26
255	0.008530533	0.262788055	3.153456659	0.069070336	69.07033639	20.72	2146.98
260	0.007969432	0.245503008	2.946036092	0.064527192	64.5271922	19.36	2166.34
265	0.007605556	0.234293579	2.811522943	0.061580943	61.58094322	18.47	2184.81
270	0.007225016	0.222570834	2.670850014	0.058499776	58.49977623	17.55	2202.36
275	0.006955584	0.214270824	2.571249885	0.056318229	56.31822907	16.90	2219.26
280	0.006868609	0.205968913	2.47162696	0.054136183	54.13618262	16.24	2235.50
285	0.006358347	0.195872589	2.350471069	0.051482498	51.4824984	15.44	2250.94
290	0.006169396	0.190051853	2.280622233	0.049952595	49.95259546	14.99	2265.93
295	0.005972236	0.183978217	2.207738602	0.048356221	48.35622126	14.51	2280.43
300	0.005775014	0.177902681	2.134832176	0.046759348	46.75934775	14.03	2294.46
305	0.005591637	0.172253656	2.067043868	0.045274577	45.27457668	13.58	2308.04
310	0.005388903	0.166008309	1.992099709	0.043633071	43.6330706	13.09	2321.13
315	0.005277798	0.162585658	1.9510279	0.042733472	42.73347248	12.82	2333.95
320	0.005163876	0.159076202	1.908914428	0.041811059	41.81105878	12.54	2346.50
325	0.005086091	0.156680016	1.880160197	0.041181253	41.18125326	12.35	2358.85
330	0.004997218	0.153942226	1.847306714	0.040461662	40.46166159	12.14	2370.99
335	0.004872271	0.150093148	1.801117778	0.039449983	39.44998274	11.83	2382.82
340	0.004791669	0.147610157	1.771321885	0.038797362	38.79736164	11.64	2394.46
345	0.004711067	0.145127166	1.741525992	0.038144741	38.14474054	11.44	2405.91
350	0.004586117	0.141278005	1.695336064	0.03713304	37.13303999	11.14	2417.05
355	0.004497246	0.138540298	1.662483572	0.03641347	36.41347003	10.92	2427.97
360	0.000444422	0.013690686	0.164288229	0.003598414	3.598414204	1.08	2429.05



Drainage 5 New gullies and ramp at boxing club, raised kerbs at McCullagh's Corner, new pipe on Guesthouse End. Catchment Area (DDF4):	42240.00 m ²
	Volume 1301.23 m ³
	Flow 0.23 m ³ /s

Design Rainfall Profile DDF 4

100years	360 Min							
Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)	
0	0.004025	0.123992463	1.48790955	0.017458139	17.45813873	5.24		
5	0.004583334	0.141192274	1.694307286	0.019879872	19.87987216	5.96	11.20	
10	0.004686111	0.144358391	1.732300692	0.020325661	20.32566146	6.10	17.30	
15	0.004763887	0.146754329	1.76105195	0.02066301	20.66300955	6.20	23.50	
20	0.004861112	0.149749396	1.796992757	0.021084715	21.08471501	6.33	29.82	
25	0.004980555	0.153428911	1.841146934	0.021602791	21.60279069	6.48	36.30	
30	0.005058334	0.155824932	1.869899183	0.02194015	21.94015041	6.58	42.89	
35	0.00514444	0.158477486	1.901729835	0.02231363	22.31363007	6.69	49.58	
40	0.005269449	0.162328464	1.947941567	0.022855848	22.85584772	6.86	56.44	
45	0.005352775	0.164895369	1.978744433	0.023217268	23.21726802	6.97	63.40	
50	0.005544445	0.170799855	2.04959826	0.02404862	24.04861959	7.21	70.62	
55	0.005747224	0.177046606	2.124559268	0.024928162	24.92816208	7.48	78.10	
60	0.005927781	0.182608744	2.191304923	0.025711311	25.71131109	7.71	85.81	
65	0.00613055	0.188855164	2.266261966	0.026590807	26.59080707	7.98	93.79	
70	0.006319447	0.194674248	2.33609098	0.027410134	27.41013417	8.22	102.01	
75	0.006616663	0.20383017	2.445962035	0.028699288	28.69928787	8.61	110.62	
80	0.006897222	0.212472941	2.549675291	0.029911619	29.91619008	8.97	119.59	
85	0.007169442	0.220858848	2.65030618	0.031096926	31.09692585	9.33	128.92	
90	0.007522224	0.231726508	2.780718095	0.032627092	32.62709231	9.79	138.71	
95	0.007905558	0.243535314	2.922423766	0.034289772	34.28977219	10.29	149.00	
100	0.008388888	0.258424588	3.101095058	0.036386182	36.38618201	10.92	159.91	
105	0.009038889	0.278448252	3.341379018	0.039205514	39.20551382	11.76	171.68	
110	0.009766669	0.300867936	3.610415228	0.042362205	42.36220534	12.71	184.38	
115	0.010833329	0.333727035	4.004724421	0.046988767	46.98876654	14.10	198.48	
120	0.012074993	0.371977222	4.463726669	0.052374393	52.37439292	15.71	214.19	
125	0.01347777	0.415190584	4.982287006	0.058458834	58.4588342	17.54	231.73	
130	0.01565556	0.482278669	5.787344026	0.067904837	67.90483658	20.37	252.10	
135	0.018058345	0.55629787	6.675574435	0.07832674	78.32674003	23.50	275.60	
140	0.020961119	0.645719494	7.748633932	0.090917305	90.9173048	27.28	302.88	
145	0.024561118	0.756619574	9.079434891	0.106532036	106.5320361	31.96	334.83	
150	0.028000015	0.862556811	10.35068173	0.121447999	121.4479989	36.43	371.27	
155	0.032116631	0.989371556	11.87245867	0.139303515	139.3035151	41.79	413.06	
160	0.036388911	1.120981646	13.45177976	0.157834216	157.8342158	47.35	460.41	
165	0.041183274	1.268674809	15.22409771	0.178629413	178.6294132	53.59	514.00	
170	0.04689447	1.444611531	17.33533838	0.203401304	203.4013036	61.02	575.02	
175	0.052650006	1.621914175	19.4629701	0.228365516	228.3655159	68.51	643.53	
180	0.053594459	1.651008606	19.81210328	0.232462012	232.4620118	69.74	713.27	
185	0.047805573	1.472678589	17.67214307	0.207353145	207.3531454	62.21	775.47	
190	0.042461136	1.308040084	15.69648101	0.184172044	184.1720438	55.25	830.73	
195	0.037199995	1.145967575	13.7516109	0.161352235	161.3522346	48.41	879.13	
200	0.032949952	1.015042511	12.18051013	0.142917985	142.9179855	42.88	922.01	
205	0.028888919	0.889939999	10.67927999	0.125303552	125.3035519	37.59	959.60	
210	0.025061063	0.772020677	9.264248123	0.108700511	108.7005113	32.61	992.21	
215	0.021772251	0.67070691	8.048482919	0.094435533	94.43553291	28.33	1020.54	
220	0.018552775	0.571529079	6.858348942	0.080471294	80.47129425	24.14	1044.68	
225	0.016108339	0.496226797	5.954721561	0.069868733	69.86873298	20.96	1065.64	
230	0.013913924	0.428626553	5.143518636	0.060350619	60.35061866	18.11	1083.75	
235	0.012269456	0.37796777	4.535613238	0.053217862	53.21786199	15.97	1099.71	
240	0.011099976	0.341941232	4.103294781	0.048145325	48.14532543	14.44	1114.15	
245	0.009944458	0.306344838	3.676138052	0.043133353	43.13335314	12.94	1127.09	
250	0.00916666	0.2823843	3.388611599	0.039759709	39.75970943	11.93	1139.02	
255	0.008530533	0.262788055	3.153456659	0.037000558	37.00055813	11.10	1150.12	
260	0.007969432	0.245503008	2.946036092	0.034566823	34.56682348	10.37	1160.49	
265	0.007605556	0.234293579	2.811522943	0.032988536	32.98853587	9.90	1170.39	
270	0.007225016	0.222570834	2.670850014	0.031337973	31.33797349	9.40	1179.79	
275	0.006955584	0.214270824	2.571249885	0.030169332	30.16933198	9.05	1188.84	
280	0.00668609	0.205968913	2.47162696	0.029000423	29.000423	8.70	1197.54	
285	0.006358347	0.195872589	2.350471069	0.027578861	27.57886054	8.27	1205.82	
290	0.006169396	0.190051853	2.280622233	0.026759301	26.75930086	8.03	1213.84	
295	0.005972236	0.183978217	2.207738602	0.025904133	25.90413293	7.77	1221.61	
300	0.005775014	0.177902681	2.134832176	0.025048698	25.04869753	7.51	1229.13	
305	0.005591637	0.172253656	2.067043868	0.024253315	24.25331472	7.28	1236.41	
310	0.005388903	0.166008309	1.992099709	0.02337397	23.37396992	7.01	1243.42	
315	0.005277798	0.162585658	1.9510279	0.022892061	22.89206069	6.87	1250.28	
320	0.005163876	0.159076202	1.908914428	0.022397929	22.39792929	6.72	1257.00	
325	0.005086091	0.156680016	1.880160197	0.022060546	22.06054632	6.62	1263.62	
330	0.004997218	0.153942226	1.847306714	0.021675065	21.67506545	6.50	1270.12	
335	0.004872271	0.150093148	1.801117778	0.021133115	21.13311526	6.34	1276.46	
340	0.004791669	0.147610157	1.771321885	0.02078351	20.78351011	6.24	1282.70	
345	0.004711067	0.145127166	1.741525992	0.020433905	20.43390497	6.13	1288.83	
350	0.004586117	0.141278005	1.695336064	0.019891943	19.89194315	5.97	1294.80	
355	0.004497246	0.138540298	1.662483572	0.019506474	19.50647391	5.85	1300.65	
360	0.000444422	0.013690686	0.164288229	0.001927649	1.927648552	0.58	1301.23	



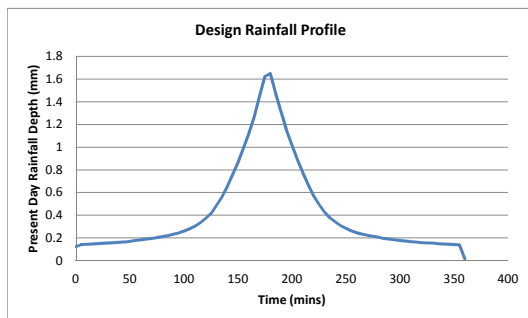
Drainage 6 New pipe in Meetinghouse Street and gullies where required. Discharges to D10.

Catchment Area (DDF 4):	46435.00 m ²
Volume	1430.46 m ³
Flow	0.26 m ³ /s

Design Rainfall Profile DDF 4

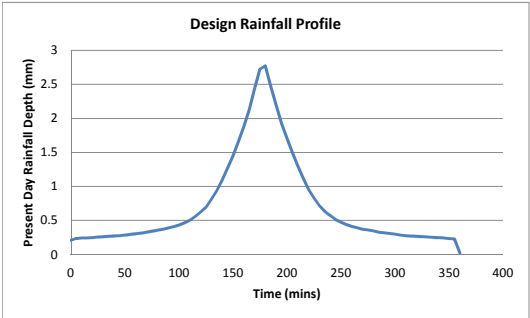
100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.019191967	19.19196666	5.76
5	0.004583334	0.141192274	1.694307286	0.021854211	21.85421079	6.56
10	0.004686111	0.144358391	1.732300692	0.022344273	22.34427296	6.70
15	0.004763887	0.146754329	1.76105195	0.022715124	22.71512425	6.81
20	0.004861112	0.149749396	1.796992757	0.023178711	23.17871074	6.95
25	0.004980555	0.153428911	1.841146934	0.023748238	23.7482383	7.12
30	0.005058334	0.155824932	1.869899183	0.024119102	24.11910238	7.24
35	0.00514444	0.158477486	1.901729835	0.024529674	24.52967358	7.36
40	0.005269449	0.162328464	1.947941567	0.025125741	25.12574075	7.54
45	0.005352775	0.164895369	1.978744433	0.025523055	25.52305493	7.66
50	0.005544445	0.170799855	2.04959826	0.026436971	26.43697089	7.93
55	0.005747224	0.177046606	2.124559268	0.027403864	27.40386378	8.22
60	0.005927781	0.182608744	2.191304923	0.02826479	28.26479003	8.48
65	0.00613055	0.188855164	2.266261966	0.029231632	29.23163178	8.77
70	0.006319447	0.194674248	2.33609098	0.030132329	30.13232907	9.04
75	0.006616663	0.20383017	2.445962035	0.031549513	31.54951308	9.46
80	0.006897222	0.212472941	2.549675291	0.03288727	32.88727004	9.87
85	0.007169442	0.220858848	2.65030618	0.034185269	34.18526874	10.26
90	0.007522224	0.231726508	2.780718095	0.035867401	35.86740132	10.76
95	0.007905558	0.243535314	2.922423766	0.037695208	37.69520767	11.31
100	0.008388888	0.258424588	3.101095058	0.039999819	39.99981917	12.00
105	0.009038889	0.278448252	3.341379018	0.043099149	43.09914853	12.93
110	0.009766669	0.300867936	3.610415228	0.046569342	46.56934198	13.97
115	0.010833329	0.333727035	4.004724421	0.051655383	51.65538291	15.50
120	0.012074993	0.371977222	4.463726669	0.057575874	57.57587441	17.27
125	0.01347777	0.415190584	4.982287006	0.064264583	64.26458253	19.28
130	0.01565556	0.482278669	5.787344026	0.0746487	74.64869996	22.39
135	0.018058345	0.55629787	6.675574435	0.086105639	86.10563858	25.83
140	0.020961119	0.645719494	7.748633932	0.099946616	99.94661573	29.98
145	0.024561118	0.756619574	9.079434891	0.1171121	117.1120998	35.13
150	0.028000015	0.862556811	10.35068173	0.133509418	133.5094183	40.05
155	0.032116631	0.989371556	11.87245867	0.153138227	153.1382273	45.94
160	0.036388911	1.120981646	13.45177976	0.173509276	173.5092758	52.05
165	0.041183274	1.268674809	15.22409771	0.196369716	196.3697159	58.91
170	0.04689447	1.444611531	17.33533838	0.223601788	223.6017882	67.08
175	0.052650006	1.621914175	19.4629701	0.251045282	251.0452824	75.31
180	0.053594459	1.651008606	19.81210328	0.255548615	255.5486155	76.66
185	0.047805573	1.472678589	17.67214307	0.227946101	227.9461011	68.38
190	0.042461136	1.308040084	15.69648101	0.202462804	202.4628043	60.74
195	0.037199995	1.145967575	13.7516109	0.177376681	177.3766812	53.21
200	0.032949952	1.015042511	12.18051013	0.157111663	157.1116633	47.13
205	0.028888919	0.889939999	10.67927999	0.13774788	137.7478795	41.32
210	0.025061063	0.772020677	9.264248123	0.119495934	119.4959338	35.85
215	0.021772251	0.67070691	8.048482919	0.103814251	103.8142512	31.14
220	0.018552775	0.571529079	6.858348942	0.088463176	88.46317587	26.54
225	0.016108339	0.496226797	5.954721561	0.076807638	76.80763769	23.04
230	0.013913924	0.428626553	5.143518636	0.066344247	66.34424662	19.90
235	0.012269456	0.37796777	4.535613238	0.058503111	58.50311131	17.55
240	0.011099976	0.341941232	4.103294781	0.052926804	52.92680366	15.88
245	0.009944458	0.306344838	3.676138052	0.047417075	47.41707512	14.23
250	0.00916666	0.2823843	3.388611599	0.043708383	43.70838323	13.11
255	0.008530533	0.262788055	3.153456659	0.040675211	40.6752111	12.20
260	0.007969432	0.245503008	2.946036092	0.037999774	37.99977388	11.40
265	0.007605556	0.234293579	2.811522943	0.036264741	36.26474107	10.88
270	0.007225016	0.222570834	2.670850014	0.034450256	34.45025566	10.34
275	0.006955584	0.214270824	2.571249885	0.033165552	33.16555233	9.95
280	0.00668609	0.205968913	2.47162696	0.031880555	31.88055497	9.56
285	0.006358347	0.195872589	2.350471069	0.030317812	30.31781225	9.10
290	0.006169396	0.190051853	2.280622233	0.029416859	29.41685927	8.83
295	0.005972236	0.183978217	2.207738602	0.028476762	28.47676166	8.54
300	0.005775014	0.177902681	2.134832176	0.02753637	27.53637003	8.26
305	0.005591637	0.172253656	2.067043868	0.026661995	26.6661995	8.00
310	0.005388903	0.166008309	1.992099709	0.025695319	25.69531944	7.71
315	0.005277798	0.162585658	1.9510279	0.02516555	25.16555015	7.55
320	0.005163876	0.159076202	1.908914428	0.024622345	24.62234486	7.39
325	0.005086091	0.156680016	1.880160197	0.024251455	24.25145521	7.28
330	0.004997218	0.153942226	1.847306714	0.023827691	23.82769091	7.15
335	0.004872271	0.150093148	1.801117778	0.023231918	23.23191778	6.97
340	0.004791669	0.147610157	1.771321885	0.022847592	22.84759214	6.85
345	0.004711067	0.145127166	1.741525992	0.022463267	22.4632665	6.74
350	0.004586117	0.141278005	1.695336064	0.021867481	21.86748059	6.56
355	0.004497246	0.138540298	1.662483572	0.021443729	21.44372907	6.43
360	0.000444422	0.013690686	0.164288229	0.00211909	2.119089974	0.64



Drainage 7	Divert pipe from Cathedral Hill to D10, collect runoff from school at entrance with gullies and discharge	Catchment Area (DDF6):	28049.00 m²
		Volume	1451.90 m³
		Flow	0.26 m³/s

Design Rainfall Profile DDF 6								
100years	360 Min							
Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)	
0	0.004025	0.20834639	2.500156678	0.019479693	19.47969296	5.84		
5	0.004583334	0.23724749	2.846969881	0.022181849	22.1818495	6.65	12.50	
10	0.004686111	0.242567564	2.91081077	0.022679259	22.67925869	6.80	19.30	
15	0.004763887	0.246593495	2.959121938	0.02305567	23.05566979	6.92	26.22	
20	0.004861112	0.251626151	3.019513813	0.023526206	23.52620637	7.06	33.28	
25	0.004980555	0.257808895	3.093706738	0.024104272	24.1042723	7.23	40.51	
30	0.005058334	0.261834964	3.142019572	0.024480696	24.48069638	7.34	47.85	
35	0.00514444	0.266292091	3.195505093	0.024897423	24.89742288	7.47	55.32	
40	0.005269449	0.272762947	3.273155358	0.025502426	25.50242629	7.65	62.97	
45	0.005352775	0.277076156	3.324913875	0.025905697	25.90569702	7.77	70.74	
50	0.005544445	0.286997552	3.44397062	0.026833314	26.83331442	8.05	78.79	
55	0.005747224	0.29749406	3.569928723	0.027814703	27.81470298	8.34	87.14	
60	0.005927781	0.306840204	3.682082445	0.028688536	28.68853625	8.61	95.74	
65	0.00613055	0.317336157	3.808033886	0.029669873	29.66987291	8.90	104.65	
70	0.006319447	0.327114052	3.925368623	0.030584073	30.58407347	9.18	113.82	
75	0.006616663	0.342498883	4.1099866	0.032022504	32.02250393	9.61	123.43	
80	0.006897222	0.357021461	4.284257537	0.033380317	33.38031657	10.01	133.44	
85	0.007169442	0.371112427	4.453349125	0.034697775	34.69777489	10.41	143.85	
90	0.007522224	0.389373518	4.672482216	0.036405126	36.40512602	10.92	154.77	
95	0.007905558	0.409216031	4.910592376	0.038260335	38.26033488	11.48	166.25	
100	0.008388888	0.434234702	5.21081642	0.040599497	40.59949715	12.18	178.43	
105	0.009038889	0.467880763	5.614569154	0.043745292	43.74529172	13.12	191.55	
110	0.009766669	0.505552893	6.066634722	0.04726751	47.26751036	14.18	205.73	
115	0.010833329	0.56076653	6.729198358	0.052429801	52.42980132	15.73	221.46	
120	0.012074993	0.625038892	7.500466703	0.058439053	58.43905293	17.53	239.00	
125	0.01347777	0.697650949	8.371811394	0.065228038	65.22803827	19.57	258.56	
130	0.01565556	0.810380062	9.72456075	0.075767835	75.76783458	22.73	281.29	
135	0.018058345	0.934755633	11.21706759	0.087396536	87.39653581	26.22	307.51	
140	0.020961119	1.085012127	13.02014552	0.101445017	101.4450171	30.43	337.95	
145	0.024561118	1.27135919	15.25631028	0.118867846	118.8678464	35.66	373.61	
150	0.028000015	1.449367113	17.39240536	0.135510994	135.5109939	40.65	414.26	
155	0.032116631	1.662455827	19.94946992	0.155434078	155.4340783	46.63	460.89	
160	0.036388911	1.883602231	22.60322677	0.17611053	176.1105299	52.83	513.72	
165	0.041183274	2.131773262	25.58127915	0.199313694	199.3136941	59.79	573.52	
170	0.04689447	2.427402368	29.12882842	0.22695403	226.9540301	68.09	641.60	
175	0.052650006	2.725326653	32.70391984	0.254808958	254.8089577	76.44	718.05	
180	0.053594459	2.774214462	33.29057354	0.259379805	259.3798048	77.81	795.86	
185	0.047805573	2.474563866	29.69476639	0.231363473	231.3634729	69.41	865.27	
190	0.042461136	2.197919322	26.37503186	0.20549813	205.4981302	61.65	926.92	
195	0.037199995	1.925586461	23.10703754	0.180035916	180.0359155	54.01	980.93	
200	0.032949952	1.705591116	20.46709339	0.159467084	159.4670841	47.84	1028.77	
205	0.028888919	1.495379495	17.94455393	0.139812998	139.8129981	41.94	1070.71	
210	0.025061063	1.297237893	15.56685472	0.121287419	121.2874189	36.39	1107.10	
215	0.021772251	1.126998855	13.52398626	0.105370636	105.3706363	31.61	1138.71	
220	0.018552775	0.960348861	11.52418633	0.089789417	89.78941735	26.94	1165.65	
225	0.016108339	0.83381731	10.00580773	0.077959139	77.95913914	23.39	1189.04	
230	0.013913924	0.720227609	8.642731314	0.067338881	67.33888073	20.20	1209.24	
235	0.012269456	0.635104898	7.62125878	0.059380191	59.38019097	17.81	1227.05	
240	0.011099976	0.574568967	6.894827609	0.053720283	53.72028322	16.12	1243.17	
245	0.009944458	0.514755814	6.177069766	0.048127953	48.12795274	14.44	1257.61	
250	0.00916666	0.474494564	5.693934766	0.04436366	44.36366007	13.31	1270.92	
255	0.008530533	0.4415667	5.298800402	0.041285015	41.28501458	12.39	1283.30	
260	0.007969432	0.412522377	4.950268521	0.038569467	38.56946715	11.57	1294.87	
265	0.007605556	0.393687005	4.724244064	0.036808423	36.80842271	11.04	1305.91	
270	0.007225016	0.373989103	4.487869236	0.034966734	34.9667345	10.49	1316.40	
275	0.006955584	0.360042471	4.320509649	0.033662771	33.66277087	10.10	1326.50	
280	0.006868609	0.346092647	4.153111758	0.032358509	32.35850881	9.71	1336.21	
285	0.006358347	0.329127642	3.949531702	0.030772337	30.77233742	9.23	1345.44	
290	0.006169396	0.319346971	3.832163657	0.029857877	29.85787734	8.96	1354.40	
295	0.005972236	0.30914135	3.709696202	0.028903686	28.90368577	8.67	1363.07	
300	0.005775014	0.298932537	3.587190444	0.027949196	27.94919577	8.38	1371.46	
305	0.005591637	0.289440395	3.473284736	0.027061712	27.0617121	8.12	1379.57	
310	0.005388903	0.278946245	3.347354945	0.026080544	26.08054412	7.82	1387.40	
315	0.005277798	0.273195114	3.278341369	0.025542833	25.54283251	7.66	1395.06	
320	0.005163876	0.267298123	3.207577473	0.024991483	24.99148348	7.50	1402.56	
325	0.005086091	0.263271776	3.159261308	0.024615033	24.61503345	7.38	1409.94	
330	0.004997218	0.258671426	3.104057109	0.024184916	24.18491607	7.26	1417.20	
335	0.004872271	0.252203762	3.026445148	0.023580211	23.5802111	7.07	1424.27	
340	0.004791669	0.248031555	2.976378663	0.023190124	23.19012364	6.96	1431.23	
345	0.004711067	0.243859348	2.926312178	0.022800036	22.80003619	6.84	1438.07	
350	0.004586117	0.237391546	2.848698551	0.022195318	22.19531824	6.66	1444.73	
355	0.004497246	0.232791335	2.793496017	0.021765214	21.76521383	6.53	1451.26	
360	0.000444422	0.023004664	0.276055969	0.002150859	2.150859408	0.65	1451.90	

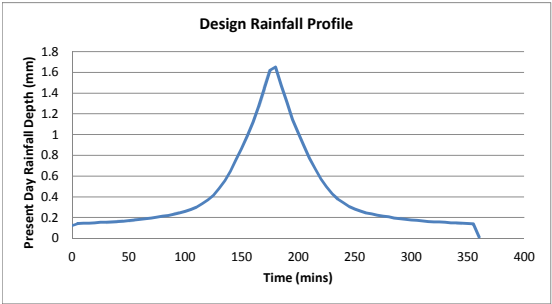


Drainage 7 Divert pipe from Cathedral Hill to D10, collect runoff from school at entrance with gullies and discharge to D10.

Catchment Area (DDF4):	76395.00 m ²
Volume:	2353.39 m ³
Flow	0.42 m ³ /s

Design Rainfall Profile DDF 4
100years 360 Min

Time (mins)	Percentage / Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	31.57468059	9.47	
5	0.004583334	0.141192274	1.694307286	35.95461254	10.79	20.26
10	0.004686111	0.144358391	1.732300692	36.76086427	11.03	31.29
15	0.004763887	0.146754329	1.76105195	37.37098992	11.21	42.50
20	0.004861112	0.149749396	1.796992757	38.13368379	11.44	53.94
25	0.004980555	0.153428911	1.841146934	39.07067223	11.72	65.66
30	0.005058334	0.155824932	1.869899183	39.68081891	11.90	77.56
35	0.00514444	0.158477486	1.901729835	40.35629188	12.11	89.67
40	0.005269449	0.162328464	1.947941567	41.33694335	12.40	102.07
45	0.005352775	0.164895369	1.978744433	41.99060583	12.60	114.67
50	0.005544445	0.170799855	2.04959826	43.49418308	13.05	127.72
55	0.005747224	0.177046606	2.124559268	45.08491813	13.53	141.24
60	0.005927781	0.182608744	2.191304923	46.50131655	13.95	155.19
65	0.00613055	0.188855164	2.266261966	48.09196747	14.43	169.62
70	0.006319447	0.194674248	2.33609098	49.57379734	14.87	184.49
75	0.006616663	0.20383017	2.445962035	51.90535268	15.57	200.06
80	0.006897222	0.212472941	2.549675291	54.10623441	16.23	216.30
85	0.007169442	0.220858848	2.65030618	56.24170573	16.87	233.17
90	0.007522224	0.231726508	2.780718095	59.00915524	17.70	250.87
95	0.007905558	0.243535314	2.922423766	62.01626768	18.60	269.48
100	0.008388888	0.258424588	3.101095058	65.80782137	19.74	289.22
105	0.009038889	0.278448252	3.341379018	70.90684725	21.27	310.49
110	0.009766669	0.300867936	3.610415228	76.61601982	22.98	333.48
115	0.010833329	0.333727035	4.004724421	84.98358948	25.50	358.97
120	0.012074993	0.371977222	4.463726669	94.72399969	28.42	387.39
125	0.01347777	0.415190584	4.982287006	105.7282822	31.72	419.11
130	0.01565556	0.482278669	5.787344026	122.812263	36.84	455.95
135	0.018058345	0.55629787	6.675574435	141.6612525	42.50	498.45
140	0.020961119	0.645719494	7.748633932	164.4324692	49.33	547.78
145	0.024561118	0.756619574	9.079434891	192.6731746	57.80	605.58
150	0.028000015	0.862556811	10.35068173	219.6500918	65.90	671.48
155	0.032116631	0.989371556	11.87245867	251.9434667	75.58	747.06
160	0.036388911	1.120981646	13.45177976	285.4579763	85.64	832.70
165	0.041183274	1.268674809	15.22409771	323.0680402	96.92	929.62
170	0.04689447	1.444611531	17.33533838	367.8703265	110.36	1039.98
175	0.052650006	1.621914175	19.4629701	413.0204447	123.91	1163.88
180	0.053594459	1.651008606	19.81210328	420.4293416	126.13	1290.01
185	0.047805573	1.472678589	17.67214307	375.0176028	112.51	1402.52
190	0.042461136	1.308040084	15.69648101	333.0924074	99.93	1502.45
195	0.037199995	1.145967575	13.7516109	291.8206431	87.55	1589.99
200	0.032949952	1.015042511	12.18051013	258.4805753	77.54	1667.54
205	0.028888919	0.889939999	10.67927999	226.6232208	67.99	1735.52
210	0.025061063	0.772020677	9.264248123	196.5950654	58.98	1794.50
215	0.021772251	0.67070691	8.048482919	170.7955146	51.24	1845.74
220	0.018552775	0.571529079	6.858348942	145.5398798	43.66	1889.40
225	0.016108339	0.496226797	5.954721561	126.3641538	37.91	1927.31
230	0.013913924	0.428626553	5.143518636	109.1497517	32.74	1960.06
235	0.012269456	0.37796777	4.535613238	96.24949259	28.87	1988.93
240	0.011099976	0.341941232	4.103294781	87.07533467	26.12	2015.05
245	0.009944458	0.306344838	3.676138052	78.01071291	23.40	2038.46
250	0.00916666	0.2823843	3.388611599	71.90916198	21.57	2060.03
255	0.008530533	0.262788055	3.153456659	66.91897819	20.08	2080.10
260	0.007969432	0.245503008	2.946036092	62.51734091	18.76	2098.86
265	0.007605556	0.234293579	2.811522943	59.66285979	17.90	2116.76
270	0.007225016	0.222570834	2.670850014	56.677663	17.00	2133.76
275	0.006955584	0.214270824	2.571249885	54.56406526	16.37	2150.13
280	0.00668609	0.205968913	2.47162696	52.44998378	15.73	2165.87
285	0.006358347	0.195872589	2.350471069	49.87895481	14.96	2180.83
290	0.006169396	0.190051853	2.280622233	48.3967043	14.52	2195.35
295	0.005972236	0.183978217	2.207738602	46.85005292	14.06	2209.40
300	0.005775014	0.177902681	2.134832176	45.3029178	13.59	2223.00
305	0.005591637	0.172253656	2.067043868	43.86439342	13.16	2236.15
310	0.005388903	0.166008309	1.992099709	42.27401591	12.68	2248.84
315	0.005277798	0.162585658	1.9510279	41.40243789	12.42	2261.26
320	0.005163876	0.159076202	1.908914428	40.50875493	12.15	2273.41
325	0.005086091	0.156680016	1.880160197	39.89856619	11.97	2285.38
330	0.004997218	0.153942226	1.847306714	39.2013879	11.76	2297.14
335	0.004872271	0.150093148	1.801117778	38.22122017	11.47	2308.61
340	0.004791669	0.147610157	1.771321885	37.58892649	11.28	2319.88
345	0.004711067	0.145127166	1.741525992	36.95663281	11.09	2330.97
350	0.004586117	0.141278005	1.695336064	35.97644405	10.79	2341.76
355	0.004497246	0.138540298	1.662483572	35.2792868	10.58	2352.35
360	0.000444422	0.013690686	0.164288229	3.48633123	1.05	2353.39



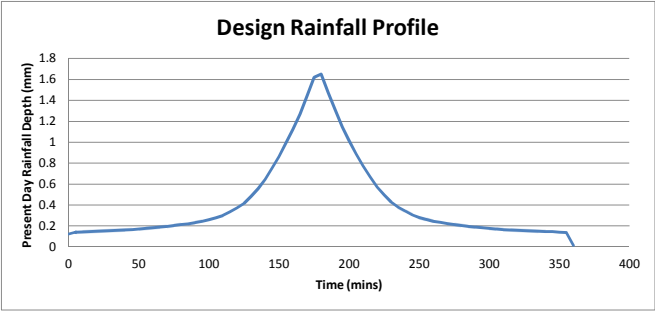
Drainage 8 New pipe in Castle Road (South) + D3 + D4. Discharge to D9.

Catchment Area (DDF4):	15148.00 m ²
Volume	466.64 m ³
Flow	0.08 m ³ /s

Design Rainfall Profile DDF 4

100years 360 Min

Time (mins)	Percentage	ay Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.006260793	6.260792742	1.88	
5	0.004583334	0.141192274	1.694307286	0.007129269	7.129268548	2.14	4.02
10	0.004686111	0.144358391	1.732300692	0.007289136	7.289136357	2.19	6.20
15	0.004763887	0.146754329	1.76105195	0.007410115	7.410115261	2.22	8.43
20	0.004861112	0.149749396	1.796992757	0.007561346	7.561346188	2.27	10.70
25	0.004980555	0.153428911	1.841146934	0.007747137	7.747137154	2.32	13.02
30	0.005058334	0.155824932	1.869899183	0.00786812	7.868120228	2.36	15.38
35	0.00514444	0.158477486	1.901729835	0.008002057	8.002056539	2.40	17.78
40	0.005269449	0.162328464	1.947941567	0.008196505	8.19650524	2.46	20.24
45	0.005352775	0.164895369	1.978744433	0.008326117	8.326116855	2.50	22.74
50	0.005544445	0.170799855	2.04959826	0.008624254	8.624254013	2.59	25.32
55	0.005747224	0.177046606	2.124559268	0.008939673	8.939673276	2.68	28.01
60	0.005927781	0.182608744	2.191304923	0.009220524	9.220524159	2.77	30.77
65	0.00613055	0.188855164	2.266261966	0.009535927	9.53592674	2.86	33.63
70	0.006319447	0.194674248	2.33609098	0.009829752	9.829751713	2.95	36.58
75	0.006616663	0.20383017	2.445962035	0.010292065	10.29206469	3.09	39.67
80	0.006897222	0.212472941	2.549675291	0.010728467	10.72846703	3.22	42.89
85	0.007169442	0.220858848	2.65030618	0.011151899	11.15189945	3.35	46.23
90	0.007522224	0.231726508	2.780718095	0.011700644	11.70064381	3.51	49.74
95	0.007905558	0.243535314	2.922423766	0.01229691	12.29690978	3.69	53.43
100	0.008388888	0.258424588	3.101095058	0.013048719	13.04871887	3.91	57.35
105	0.009038889	0.278448252	3.341379018	0.01405978	14.05978038	4.22	61.57
110	0.009766669	0.300867936	3.610415228	0.015191825	15.19182497	4.56	66.12
115	0.010833329	0.333727035	4.004724421	0.01685099	16.85099042	5.06	71.18
120	0.012074993	0.371977222	4.463726669	0.01878237	18.78236989	5.63	76.81
125	0.01347777	0.415190584	4.982287006	0.020964357	20.96435655	6.29	83.10
130	0.01565556	0.482278669	5.787344026	0.024351858	24.35185759	7.31	90.41
135	0.018058345	0.55629787	6.675574435	0.028089334	28.08933376	8.43	98.83
140	0.020961119	0.645719494	7.748633932	0.03260453	32.60452967	9.78	108.62
145	0.024561118	0.756619574	9.079434891	0.038204244	38.20424437	11.46	120.08
150	0.028000015	0.862556811	10.35068173	0.043553369	43.55336856	13.07	133.14
155	0.032116631	0.989371556	11.87245867	0.049956668	49.95666776	14.99	148.13
160	0.036388911	1.120981646	13.45177976	0.0566021	56.60209994	16.98	165.11
165	0.041183274	1.268674809	15.22409771	0.06405962	64.05962004	19.22	184.33
170	0.04689447	1.444611531	17.33533838	0.072943252	72.94325159	21.88	206.21
175	0.052650006	1.621914175	19.4629701	0.081895853	81.89585308	24.57	230.78
180	0.053594459	1.651008606	19.81210328	0.083364928	83.3649279	25.01	255.79
185	0.047805573	1.472678589	17.67214307	0.074360451	74.3604509	22.31	278.10
190	0.042461136	1.308040084	15.69648101	0.066047304	66.04730397	19.81	297.91
195	0.037199995	1.145967575	13.7516109	0.057863723	57.86372277	17.36	315.27
200	0.032949952	1.015042511	12.18051013	0.05125288	51.25287983	15.38	330.65
205	0.028888919	0.889939999	10.67927999	0.044936037	44.93603702	13.48	344.13
210	0.025061063	0.772020677	9.264248123	0.038981897	38.98189738	11.69	355.82
215	0.021772251	0.67070691	8.048482919	0.033866228	33.86622757	10.16	365.98
220	0.018552775	0.571529079	6.858348942	0.028858408	28.85840827	8.66	374.64
225	0.016108339	0.496226797	5.954721561	0.025056145	25.05614506	7.52	382.16
230	0.013913924	0.428626553	5.143518636	0.021642783	21.64278341	6.49	388.65
235	0.012269456	0.37796777	4.535613238	0.019084853	19.08485259	5.73	394.38
240	0.011099976	0.341941232	4.103294781	0.017265753	17.2657526	5.18	399.56
245	0.009944458	0.306344838	3.676138052	0.015468372	15.468372	4.64	404.20
250	0.00916666	0.2823843	3.388611599	0.014258525	14.25852458	4.28	408.47
255	0.008530533	0.262788055	3.153456659	0.013269045	13.26904485	3.98	412.45
260	0.007969432	0.245503008	2.946036092	0.012396265	12.3962652	3.72	416.17
265	0.007605556	0.234293579	2.811522943	0.011830264	11.83026376	3.55	419.72
270	0.007225016	0.222570834	2.670850014	0.011238343	11.23834334	3.37	423.09
275	0.006955584	0.214270824	2.571249885	0.010819248	10.81924813	3.25	426.34
280	0.00668609	0.205968913	2.47162696	0.010400057	10.400057	3.12	429.46
285	0.006358347	0.195872589	2.350471069	0.00989026	9.890259931	2.97	432.43
290	0.006169396	0.190051853	2.280622233	0.009596352	9.59635155	2.88	435.31
295	0.005972236	0.183978217	2.207738602	0.009289673	9.289673429	2.79	438.09
300	0.005775014	0.177902681	2.134832176	0.008982899	8.982899389	2.69	440.79
305	0.005591637	0.172253656	2.067043868	0.008697661	8.697661254	2.61	443.40
310	0.005388903	0.166008309	1.992099709	0.008382313	8.382312888	2.51	445.91
315	0.005277798	0.162585658	1.9510279	0.008209492	8.209491841	2.46	448.37
320	0.005163876	0.159076202	1.908914428	0.008032288	8.032287712	2.41	450.78
325	0.005086091	0.156680016	1.880160197	0.007911296	7.911296297	2.37	453.16
330	0.004997218	0.153942226	1.847306714	0.007773056	7.773056141	2.33	455.49
335	0.004872271	0.150093148	1.801117778	0.007578703	7.57870336	2.27	457.76
340	0.004791669	0.147610157	1.771321885	0.007453329	7.453328863	2.24	460.00
345	0.004711067	0.145127166	1.741525992	0.007327954	7.327954367	2.20	462.20
350	0.004586117	0.141278005	1.695336064	0.007133597	7.133597415	2.14	464.34
355	0.004497246	0.138540298	1.662483572	0.006995361	6.995361429	2.10	466.44
360	0.000444422	0.013690686	0.164288229	0.000691288	0.691288359	0.21	466.64



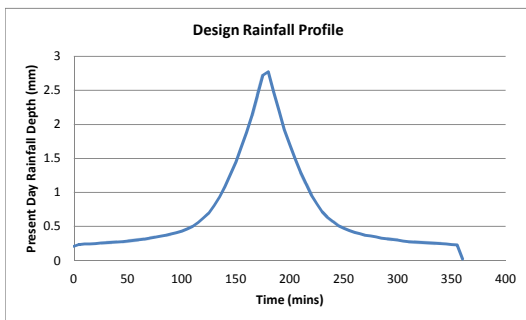
Secondary 5 Divert flow into field, open channel, new road culvert.

Catchment Area (DDF6):	81795.00 m ²
Volume	4233.96 m ³
Flow	0.76 m ³ /s

Design Rainfall Profile DDF 6

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.20834639	2.500156678	0.056805643	56.80564318	17.04	
5	0.004583334	0.23724749	2.846969881	0.064685528	64.68552817	19.41	36.45
10	0.004686111	0.242567564	2.91081077	0.066136046	66.13604636	19.84	56.29
15	0.004763887	0.246593495	2.959121938	0.067233716	67.23371637	20.17	76.46
20	0.004861112	0.251626151	3.019513813	0.06860587	68.60587009	20.58	97.04
25	0.004980555	0.257808895	3.093706738	0.070291595	70.29159517	21.09	118.13
30	0.005058334	0.261834964	3.142019572	0.071389303	71.38930302	21.42	139.54
35	0.00514444	0.266292091	3.195505093	0.072604539	72.60453863	21.78	161.33
40	0.005269449	0.272762947	3.273155358	0.074368817	74.36881737	22.31	183.64
45	0.005352775	0.277076156	3.324913875	0.075544814	75.54481399	22.66	206.30
50	0.005544445	0.286997552	3.44397062	0.078249882	78.24988246	23.47	229.77
55	0.005747224	0.29749406	3.569928723	0.081111756	81.11175552	24.33	254.11
60	0.005927781	0.306840204	3.682082445	0.083659982	83.65998155	25.10	279.21
65	0.00613055	0.317336157	3.808033886	0.086521703	86.52170326	25.96	305.16
70	0.006319447	0.327114052	3.925368623	0.089187646	89.18764626	26.76	331.92
75	0.006616663	0.342498883	4.1099866	0.093382321	93.38232054	28.01	359.93
80	0.006897222	0.357021461	4.284257537	0.097341901	97.34190145	29.20	389.14
85	0.007169442	0.371112427	4.453349125	0.101183803	101.1838032	30.36	419.49
90	0.007522224	0.389373518	4.672482216	0.10616269	106.1626897	31.85	451.34
95	0.007905558	0.409216031	4.910592376	0.111572751	111.5727509	33.47	484.81
100	0.008388888	0.434234702	5.21081642	0.118394091	118.3940914	35.52	520.33
105	0.009038889	0.467880763	5.614569154	0.12756769	127.56769	38.27	558.60
110	0.009766669	0.505552893	6.066634722	0.137838996	137.8389964	41.35	599.95
115	0.010833329	0.56076653	6.729198358	0.152892994	152.8929944	45.87	645.82
120	0.012074993	0.625038892	7.500466703	0.170416854	170.4168539	51.13	696.95
125	0.01347777	0.697650949	8.371811394	0.190214531	190.2145314	57.06	754.01
130	0.01565556	0.810380062	9.72456075	0.220950124	220.950124	66.29	820.29
135	0.018058345	0.934755633	11.21706759	0.254861123	254.8611233	76.46	896.75
140	0.020961119	1.085012127	13.02014552	0.295828556	295.8285563	88.75	985.50
145	0.024561118	1.27135919	15.25631028	0.346636083	346.6360832	103.99	1089.49
150	0.028000015	1.449367113	17.39240536	0.395169943	395.1699434	118.55	1208.04
155	0.032116631	1.662455827	19.94946992	0.453268581	453.2685813	135.98	1344.02
160	0.036388911	1.883602231	22.60322677	0.513564148	513.5641483	154.07	1498.09
165	0.041183274	2.131773262	25.58127915	0.58122798	581.22798	174.37	1672.46
170	0.04689447	2.427402368	29.12882842	0.661831256	661.8312558	198.55	1871.01
175	0.052650006	2.725326653	32.70391984	0.743060312	743.060312	222.92	2093.93
180	0.053594459	2.774214462	33.29057354	0.756389573	756.3895729	226.92	2320.85
185	0.047805573	2.474563866	29.69476639	0.674689838	674.689838	202.41	2523.25
190	0.042461136	2.197919322	26.37503186	0.599262703	599.2627031	179.78	2703.03
195	0.037199995	1.925586461	23.10703754	0.525011149	525.0111487	157.50	2860.54
200	0.032949952	1.705591116	20.46709339	0.465029418	465.0294178	139.51	3000.04
205	0.028888919	1.495379495	17.94455393	0.407715219	407.7152192	122.31	3122.36
210	0.025061063	1.297237893	15.56685472	0.353691912	353.6919116	106.11	3228.47
215	0.021772251	1.126998855	13.52398626	0.307276238	307.2762378	92.18	3320.65
220	0.018552775	0.960348861	11.52418633	0.261839117	261.839117	78.55	3399.20
225	0.016108339	0.83381731	10.00580773	0.22734029	227.3402897	68.20	3467.40
230	0.013913924	0.720227609	8.642731314	0.196370058	196.3700577	58.91	3526.31
235	0.012269456	0.635104898	7.62125878	0.173161351	173.1613505	51.95	3578.26
240	0.011099976	0.574568967	6.894827609	0.156656229	156.656229	47.00	3625.26
245	0.009944458	0.514755814	6.177069766	0.140348173	140.3481726	42.10	3667.36
250	0.00916666	0.474494564	5.693934766	0.129370943	129.3709428	38.81	3706.17
255	0.008530533	0.4415667	5.298800402	0.120393161	120.3931608	36.12	3742.29
260	0.007969432	0.412522377	4.950268521	0.112474226	112.474226	33.74	3776.03
265	0.007605556	0.393687005	4.724244064	0.107338762	107.338762	32.20	3808.24
270	0.007225016	0.373989103	4.487869236	0.101968129	101.9681289	30.59	3838.83
275	0.006955584	0.360042471	4.320509649	0.09816558	98.16557964	29.45	3868.28
280	0.00668609	0.346092647	4.153111758	0.09436216	94.36216007	28.31	3896.59
285	0.006358347	0.329127642	3.949531702	0.089736652	89.73665154	26.92	3923.51
290	0.006169396	0.319346971	3.832163657	0.087069952	87.06995176	26.12	3949.63
295	0.005972236	0.30914135	3.709696202	0.084287389	84.28738913	25.29	3974.91
300	0.005775014	0.298932537	3.587190444	0.081503956	81.50395621	24.45	3999.36
305	0.005591637	0.289440395	3.473284736	0.078915924	78.9159236	23.67	4023.04
310	0.005388903	0.278946245	3.347354945	0.076054694	76.0546938	22.82	4045.86
315	0.005277798	0.273195114	3.278341369	0.074486648	74.48664785	22.35	4068.20
320	0.005163876	0.267298123	3.207577473	0.072878833	72.87883316	21.86	4090.07
325	0.005086091	0.263271776	3.159261308	0.07178105	71.78104963	21.53	4111.60
330	0.004997218	0.258671426	3.104057109	0.070526764	70.52676423	21.16	4132.76
335	0.004872271	0.252203762	3.026445148	0.068763356	68.76335579	20.63	4153.39
340	0.004791669	0.248031555	2.976378663	0.067625804	67.62580353	20.29	4173.67
345	0.004711067	0.243859348	2.926312178	0.066488251	66.48825128	19.95	4193.62
350	0.004586117	0.237391546	2.848698551	0.064724805	64.724805	19.42	4213.04
355	0.004497246	0.232791335	2.793496017	0.063470557	63.47055743	19.04	4232.08
360	0.000444422	0.023004664	0.276055969	0.006272222	6.272221658	1.88	4233.96

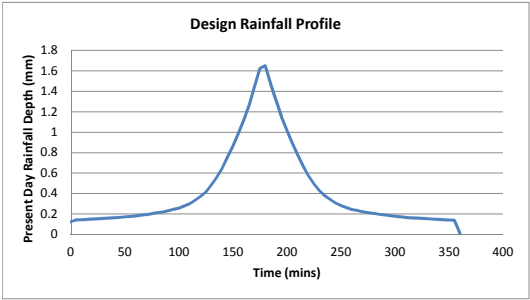


Secondary 5 Divert flow into field, open channel, new road culvert.

Catchment Area (DDF4):	7957.00 m ²
Volume	245.12 m ³
Flow	0.04 m ³ /s

Design Rainfall Profile DDF 4

100years	360 Min						
	Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³) Cum. Volume (m ³)
	0	0.004025	0.123992463	1.48790955	0.003288693	3.288693415	0.99
	5	0.004583334	0.141192274	1.694307286	0.00374489	3.744889744	1.12 2.11
	10	0.004686111	0.144358391	1.732300692	0.003828866	3.828865725	1.15 3.26
	15	0.004763887	0.146754329	1.76105195	0.003892414	3.892413991	1.17 4.43
	20	0.004861112	0.149749396	1.796992757	0.003971853	3.971853157	1.19 5.62
	25	0.004980555	0.153428911	1.841146934	0.004069446	4.069446154	1.22 6.84
	30	0.005058334	0.155824932	1.869899183	0.004132997	4.13299661	1.24 8.08
	35	0.00514444	0.158477486	1.901729835	0.004203351	4.203351194	1.26 9.34
	40	0.005269449	0.162328464	1.947941567	0.004305492	4.305491959	1.29 10.63
	45	0.005352775	0.164895369	1.978744433	0.004373575	4.373574849	1.31 11.94
	50	0.005544445	0.170799855	2.04959826	0.004530181	4.530181488	1.36 13.30
	55	0.005747224	0.177046606	2.124559268	0.004695866	4.695866138	1.41 14.71
	60	0.005927781	0.182608744	2.191304923	0.004843393	4.843392575	1.45 16.16
	65	0.00613055	0.188855164	2.266261966	0.005009068	5.009068462	1.50 17.67
	70	0.006319447	0.194674248	2.33609098	0.00516341	5.16340998	1.55 19.22
	75	0.006616663	0.20383017	2.445962035	0.005406256	5.406255531	1.62 20.84
	80	0.006897222	0.212472941	2.549675291	0.005635491	5.635490637	1.69 22.53
	85	0.007169442	0.220858848	2.65030618	0.005857913	5.857912854	1.76 24.29
	90	0.007522224	0.231726508	2.780718095	0.006146159	6.146159412	1.84 26.13
	95	0.007905558	0.243535314	2.922423766	0.006459368	6.459368308	1.94 28.07
	100	0.008388888	0.258424588	3.101095058	0.006854281	6.854281493	2.06 30.12
	105	0.009038889	0.278448252	3.341379018	0.007385376	7.385375791	2.22 32.34
	110	0.009766669	0.300867936	3.610415228	0.007980021	7.980020547	2.39 34.73
	115	0.010833329	0.333727035	4.004724421	0.008851553	8.851553394	2.66 37.39
	120	0.012074993	0.371977222	4.463726669	0.009866076	9.866075863	2.96 40.35
	125	0.01347777	0.415190584	4.982287006	0.011012238	11.01223825	3.30 43.65
	130	0.01565556	0.482278669	5.787344026	0.012791638	12.79163789	3.84 47.49
	135	0.018058345	0.55629787	6.675574435	0.014754874	14.75487383	4.43 51.92
	140	0.020961119	0.645719494	7.748633932	0.017126633	17.12663339	5.14 57.05
	145	0.024561118	0.756619574	9.079434891	0.020068073	20.06807317	6.02 63.07
	150	0.028000015	0.862556811	10.35068173	0.022877882	22.87788181	6.86 69.94
	155	0.032116631	0.989371556	11.87245867	0.026241432	26.24143157	7.87 77.81
	160	0.036388911	1.120981646	13.45177976	0.02973217	29.73216987	8.92 86.73
	165	0.041183274	1.268674809	15.22409771	0.033649485	33.64948486	10.09 96.83
	170	0.04689447	1.444611531	17.33533838	0.038315913	38.31591318	11.49 108.32
	175	0.052650006	1.621914175	19.4629701	0.04301857	43.0185703	12.91 121.23
	180	0.053594459	1.651008606	19.81210328	0.043790252	43.7902516	13.14 134.36
	185	0.047805573	1.472678589	17.67214307	0.039060345	39.06034512	11.72 146.08
	190	0.042461136	1.308040084	15.69648101	0.034693583	34.69358316	10.41 156.49
	195	0.037199995	1.145967575	13.7516109	0.03039488	30.39487999	9.12 165.61
	200	0.032949952	1.015042511	12.18051013	0.026922311	26.92231085	8.08 173.68
	205	0.028888919	0.889939999	10.67927999	0.023604175	23.60417524	7.08 180.77
	210	0.025061063	0.772020677	9.264248123	0.020476562	20.47656175	6.14 186.91
	215	0.021772251	0.67070691	8.048482919	0.017789383	17.78938294	5.34 192.24
	220	0.018552775	0.571529079	6.858348942	0.015158856	15.15885626	4.55 196.79
	225	0.016108339	0.496226797	5.954721561	0.013161589	13.16158874	3.95 200.74
	230	0.013913924	0.428626553	5.143518636	0.011368605	11.36860494	3.41 204.15
	235	0.012269456	0.37796777	4.535613238	0.010024965	10.02496515	3.01 207.16
	240	0.011099976	0.341941232	4.103294781	0.009069421	9.069421271	2.72 209.88
	245	0.009944458	0.306344838	3.676138052	0.008125286	8.125286245	2.44 212.32
	250	0.00916666	0.2823843	3.388611599	0.007489773	7.489772915	2.25 214.56
	255	0.008530533	0.262788055	3.153456659	0.006970015	6.970015177	2.09 216.66
	260	0.007969432	0.245503008	2.946036092	0.006511558	6.511558108	1.95 218.61
	265	0.007605556	0.234293579	2.811522943	0.006214247	6.214246683	1.86 220.47
	270	0.007225016	0.222570834	2.670850014	0.00590332	5.903320433	1.77 222.24
	275	0.006955584	0.214270824	2.571249885	0.005683176	5.683176481	1.70 223.95
	280	0.00668609	0.205968913	2.47162696	0.005462982	5.462982145	1.64 225.59
	285	0.006358347	0.195872589	2.350471069	0.005195194	5.195193971	1.56 227.15
	290	0.006169396	0.190051853	2.280622233	0.005040809	5.040808641	1.51 228.66
	295	0.005972236	0.183978217	2.207738602	0.004879716	4.879715572	1.46 230.12
	300	0.005775014	0.177902681	2.134832176	0.004718572	4.718572118	1.42 231.54
	305	0.005591637	0.172253656	2.067043868	0.004568741	4.568741127	1.37 232.91
	310	0.005388903	0.166008309	1.992099709	0.004403094	4.403093718	1.32 234.23
	315	0.005277798	0.162585658	1.9510279	0.004312314	4.312313611	1.29 235.52
	320	0.005163876	0.159076202	1.908914428	0.004219231	4.219231141	1.27 236.79
	325	0.005086091	0.156680016	1.880160197	0.004155676	4.155676303	1.25 238.04
	330	0.004997218	0.153942226	1.847306714	0.004083061	4.083060979	1.22 239.26
	335	0.004872721	0.150093148	1.801117778	0.003980971	3.980970599	1.19 240.46
	340	0.004791669	0.147610157	1.771321885	0.003915113	3.915113399	1.17 241.63
	345	0.004711067	0.145127166	1.741525992	0.003849256	3.849256199	1.15 242.78
	350	0.004586117	0.141278005	1.695336064	0.003747164	3.747163628	1.12 243.91
	355	0.004497246	0.138540298	1.662483572	0.00367455	3.674550495	1.10 245.01
	360	0.000444422	0.013690686	0.164288229	0.000363123	0.363122621	0.11 245.12

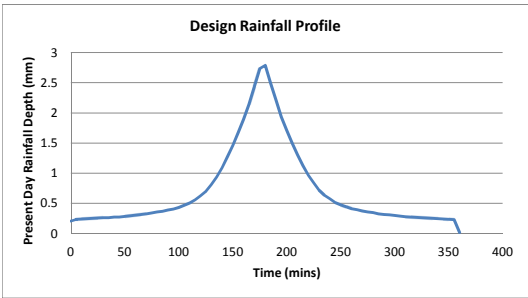


Secondary 6 Embankment to create storage area above town.

Catchment Area (DDF3):	10725.00 m ²
Volume	557.52 m ³
Flow	0.10 m ³ /s

Design Rainfall Profile DDF3
100years 360 Min

Time (mins)	Percentage t	Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.007480126	7.480125705	2.24	
5	0.004583334	0.238258552	2.859102619	0.008517743	8.517743322	2.56	4.80
10	0.004686111	0.243601298	2.923215574	0.008708746	8.708746398	2.61	7.41
15	0.004763887	0.247644386	2.971732627	0.008853287	8.853286784	2.66	10.07
20	0.004861112	0.252698489	3.03238187	0.009033971	9.033970987	2.71	12.78
25	0.004980555	0.258907581	3.106890978	0.009255946	9.255946038	2.78	15.55
30	0.005058334	0.262950809	3.155409703	0.009400491	9.400491407	2.82	18.38
35	0.00514444	0.26742693	3.20912316	0.009560513	9.560512747	2.87	21.24
40	0.005269449	0.273925362	3.287104342	0.009792832	9.792831685	2.94	24.18
45	0.005352775	0.278256953	3.339083434	0.009947686	9.947686064	2.98	27.17
50	0.005544445	0.28822063	3.458647556	0.010303888	10.30388751	3.09	30.26
55	0.005747224	0.29876187	3.585142445	0.010680737	10.68073687	3.20	33.46
60	0.005927781	0.308147844	3.697774126	0.011016285	11.01628542	3.30	36.77
65	0.00613055	0.318688527	3.824262326	0.011393115	11.39311485	3.42	40.18
70	0.006319447	0.328508092	3.9420971	0.011744164	11.74416428	3.52	43.71
75	0.006616663	0.343958488	4.127501851	0.012296516	12.29651593	3.69	47.40
80	0.006897222	0.358542956	4.302515466	0.012817911	12.81791066	3.85	51.24
85	0.007169442	0.372693972	4.47232766	0.013323809	13.32380949	4.00	55.24
90	0.007522224	0.391032885	4.692394616	0.013979426	13.97942563	4.19	59.43
95	0.007905558	0.41095996	4.931519514	0.014691819	14.69181855	4.41	63.84
100	0.008388888	0.43608525	5.233023002	0.015590048	15.59004769	4.68	68.52
105	0.009038889	0.469874698	5.638496382	0.01679802	16.79802047	5.04	73.56
110	0.009766669	0.507707374	6.092488487	0.018150539	18.15053862	5.45	79.00
115	0.010833329	0.56315631	6.757875725	0.020132838	20.1328381	6.04	85.04
120	0.012074993	0.627702578	7.532430932	0.022440367	22.44036715	6.73	91.77
125	0.01347777	0.700624081	8.407488974	0.025047311	25.0473109	7.51	99.29
130	0.01565556	0.813833604	9.76600325	0.029094551	29.09455135	8.73	108.02
135	0.018058345	0.938739217	11.26487061	0.033559927	33.55992702	10.07	118.08
140	0.020961119	1.089636049	13.07563259	0.038954489	38.95448876	11.69	129.77
145	0.024561118	1.276777255	15.32132706	0.045644787	45.64478687	13.69	143.46
150	0.028000015	1.455543783	17.46652539	0.05203569	52.03569023	15.61	159.07
155	0.032116631	1.669540602	20.03448723	0.059686077	59.68607653	17.91	176.98
160	0.036388911	1.891629451	22.69955341	0.067625753	67.62575287	20.29	197.27
165	0.041183274	2.140858096	25.69029715	0.076535677	76.53567692	22.96	220.23
170	0.04689447	2.437747064	29.25296477	0.087149458	87.14945755	26.14	246.37
175	0.052650006	2.736940993	32.84329191	0.09784564	97.84564049	29.35	275.73
180	0.053594459	2.786037143	33.43244571	0.099600828	99.60082786	29.88	305.61
185	0.047805573	2.485109547	29.82131456	0.088842666	88.84266629	26.65	332.26
190	0.042461136	2.207286045	26.48743255	0.078910476	78.91047613	23.67	355.93
195	0.037199995	1.933792602	23.20551123	0.069133086	69.13308553	20.74	376.67
200	0.032949952	1.712859718	20.55431662	0.061234735	61.23473492	18.37	395.04
205	0.028888919	1.501752252	18.02102702	0.053687643	53.687643	16.11	411.15
210	0.025061063	1.302766244	15.63319493	0.046573893	46.57389322	13.97	425.12
215	0.021772251	1.131801709	13.58162051	0.040461911	40.46191111	12.14	437.26
220	0.018552775	0.964441515	11.57329817	0.034478784	34.47878415	10.34	447.60
225	0.016108339	0.837370733	10.0484488	0.029936004	29.93600371	8.98	456.59
230	0.013913924	0.723296955	8.679563455	0.025857866	25.85786613	7.76	464.34
235	0.012269456	0.637811482	7.65373778	0.02280176	22.80176047	6.84	471.18
240	0.011099976	0.577017569	6.924210827	0.020628378	20.62837809	6.19	477.37
245	0.009944458	0.516949514	6.203394165	0.018480945	18.48094512	5.54	482.92
250	0.00916666	0.476516685	5.718200221	0.017035471	17.03547149	5.11	488.03
255	0.008530533	0.443448495	5.32138194	0.015853284	15.85328369	4.76	492.78
260	0.007969432	0.414280395	4.971364744	0.014810524	14.81052413	4.44	497.23
265	0.007605556	0.395364754	4.744377054	0.01413429	14.13428997	4.24	501.47
270	0.007225016	0.375582907	4.506994883	0.013427089	13.42708892	4.03	505.49
275	0.006955584	0.361576839	4.338922071	0.012926372	12.926372	3.88	509.37
280	0.006686609	0.347567566	4.170810792	0.01242554	12.42554049	3.73	513.10
285	0.006358347	0.330530263	3.966363152	0.011816457	11.81645689	3.54	516.64
290	0.006169396	0.320707911	3.848494929	0.011465308	11.46530781	3.44	520.08
295	0.005972236	0.310458797	3.725505563	0.011098902	11.09890199	3.33	523.41
300	0.005775014	0.300206477	3.602477729	0.010732382	10.73238157	3.22	526.63
305	0.005591637	0.290673883	3.488086597	0.010391591	10.39159132	3.12	529.75
310	0.005388903	0.280135012	3.36162014	0.010014827	10.01482667	3.00	532.76
315	0.005277798	0.274359371	3.292312453	0.009808348	9.808347517	2.94	535.70
320	0.005163876	0.268437249	3.221246988	0.009596632	9.596631651	2.88	538.58
325	0.005086091	0.264393743	3.172724917	0.009452076	9.452076316	2.84	541.41
330	0.004997218	0.259773788	3.117285458	0.009286913	9.286912927	2.79	544.20
335	0.004872271	0.253278562	3.039342743	0.009054709	9.054708589	2.72	546.91
340	0.004791669	0.249088574	2.989062893	0.008904917	8.904916537	2.67	549.59
345	0.004711067	0.244898587	2.938783044	0.008755124	8.755124484	2.63	552.21
350	0.004586117	0.238403221	2.860838656	0.008522915	8.522915164	2.56	554.77
355	0.004497246	0.233783406	2.80540087	0.008357757	8.357756758	2.51	557.28
360	0.000444422	0.023102701	0.277232418	0.000825922	0.825921578	0.25	557.52



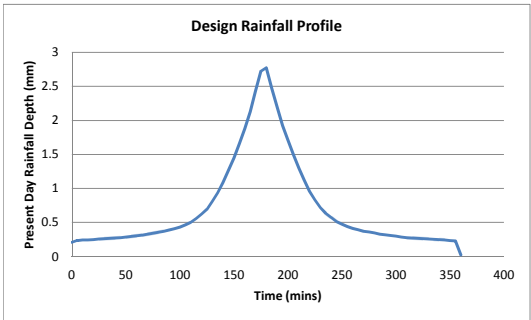
Secondary 6 Embankment to create storage area above town.

Catchment Area (DDF6):	26647.00 m ²
Volume	1379.33 m ³
Flow	0.25 m ³ /s

Design Rainfall Profile DDF 6

100years 360 Min

Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.20834639	2.500156678	0.018506021	18.50602083	5.55	
5	0.004583334	0.23724749	2.846969881	0.021073113	21.07311289	6.32	11.87
10	0.004686111	0.242567564	2.91081077	0.02154566	21.5456596	6.46	18.34
15	0.004763887	0.246593495	2.959121938	0.021903256	21.90325619	6.57	24.91
20	0.004861112	0.251626151	3.019513813	0.022350273	22.35027349	6.71	31.61
25	0.004980555	0.257808895	3.093706738	0.022899445	22.8994454	6.87	38.48
30	0.005058334	0.261834964	3.142019572	0.023257054	23.25705431	6.98	45.46
35	0.00514444	0.266292091	3.195505093	0.023652951	23.65295117	7.10	52.56
40	0.005269449	0.272762947	3.273155358	0.024227714	24.22771412	7.27	59.82
45	0.005352775	0.277076156	3.324913875	0.024610828	24.61082778	7.38	67.21
50	0.005544445	0.286997552	3.44397062	0.025492079	25.4920792	7.65	74.86
55	0.005747224	0.29749406	3.569928723	0.026424414	26.42441408	7.93	82.78
60	0.005927781	0.306840204	3.682082445	0.02725457	27.2545697	8.18	90.96
65	0.00613055	0.317336157	3.808033886	0.028186855	28.18685527	8.46	99.42
70	0.006319447	0.327114052	3.925368623	0.02905536	29.05536047	8.72	108.13
75	0.006616663	0.342498883	4.1099866	0.030421892	30.42189248	9.13	117.26
80	0.006897222	0.357021461	4.284257537	0.031711836	31.71183627	9.51	126.77
85	0.007169442	0.371112427	4.453349125	0.032963443	32.96344281	9.89	136.66
90	0.007522224	0.389373518	4.672482216	0.034585454	34.58545378	10.38	147.04
95	0.007905558	0.409216031	4.910592376	0.036347932	36.34793196	10.90	157.94
100	0.008388888	0.434234702	5.21081642	0.038570174	38.57017365	11.57	169.51
105	0.009038889	0.467880763	5.614569154	0.041558729	41.55872896	12.47	181.98
110	0.009766669	0.505552893	6.066634722	0.044904893	44.90489318	13.47	195.45
115	0.010833329	0.56076653	6.729198358	0.049809152	49.8091524	14.94	210.39
120	0.012074993	0.625038892	7.500466703	0.055518038	55.51803784	16.66	227.05
125	0.01347777	0.697650949	8.371811394	0.061967683	61.96768284	18.59	245.64
130	0.01565556	0.810380062	9.72456075	0.071980658	71.98065842	21.59	267.23
135	0.018058345	0.934755633	11.21706759	0.083028111	83.02811115	24.91	292.14
140	0.020961119	1.085012127	13.02014552	0.096374394	96.3743938	28.91	321.05
145	0.024561118	1.27135919	15.25631028	0.112926361	112.9263611	33.88	354.93
150	0.028000015	1.449367113	17.39240536	0.128737618	128.7376182	38.62	393.55
155	0.032116631	1.662455827	19.94946992	0.147664868	147.6648681	44.30	437.85
160	0.036388911	1.883602231	22.60322677	0.167307829	167.3078288	50.19	488.05
165	0.041183274	2.131773262	25.58127915	0.189351207	189.3512071	56.81	544.85
170	0.04689447	2.427402368	29.12882842	0.21560997	215.6099697	64.68	609.53
175	0.052650006	2.725326653	32.70391984	0.242072598	242.0725978	72.62	682.16
180	0.053594459	2.774214462	33.29057354	0.246414976	246.4149759	73.92	756.08
185	0.047805573	2.474563866	29.69476639	0.219799011	219.7990111	65.94	822.02
190	0.042461136	2.197919322	26.37503186	0.195226521	195.2265206	58.57	880.59
195	0.037199995	1.925586461	23.10703754	0.171037008	171.0370081	51.31	931.90
200	0.032949952	1.705591116	20.46709339	0.151496288	151.4962882	45.45	977.35
205	0.028888919	1.495379495	17.94455393	0.132824591	132.8245913	39.85	1017.20
210	0.025061063	1.297237893	15.56685472	0.115224994	115.2249938	34.57	1051.76
215	0.021772251	1.126998855	13.52398626	0.100103795	100.103795	30.03	1081.79
220	0.018552775	0.960348861	11.52418633	0.085301387	85.301387	25.59	1107.38
225	0.016108339	0.83381731	10.00580773	0.074062433	74.06243291	22.22	1129.60
230	0.013913924	0.720227609	8.642731314	0.063973017	63.97301703	19.19	1148.79
235	0.012269456	0.635104898	7.62125878	0.056412134	56.41213408	16.92	1165.72
240	0.011099976	0.574568967	6.894827609	0.051035131	51.03513092	15.31	1181.03
245	0.009944458	0.514755814	6.177069766	0.045722327	45.72232724	13.72	1194.75
250	0.00916666	0.474494564	5.693934766	0.042146189	42.14618881	12.64	1207.39
255	0.008530533	0.4415667	5.298800402	0.039221426	39.2214262	11.77	1219.16
260	0.007969432	0.412522377	4.950268521	0.036641613	36.64161258	10.99	1230.15
265	0.007605556	0.393687005	4.724244064	0.034968592	34.9685921	10.49	1240.64
270	0.007225016	0.373989103	4.487869236	0.033218959	33.21895876	9.97	1250.60
275	0.006955584	0.360042471	4.320509649	0.031980172	31.98017239	9.59	1260.20
280	0.00668609	0.346092647	4.153111758	0.030741103	30.7411025	9.22	1269.42
285	0.006358347	0.329127642	3.949531702	0.029234214	29.23421424	8.77	1278.19
290	0.006169396	0.319346971	3.832163657	0.028365462	28.36546249	8.51	1286.70
295	0.005972236	0.30914135	3.709696202	0.027458965	27.4589652	8.24	1294.94
300	0.005775014	0.298932537	3.587190444	0.026552184	26.55218438	7.97	1302.90
305	0.005591637	0.289440395	3.473284736	0.025709061	25.70906065	7.71	1310.62
310	0.005388903	0.278946245	3.347354945	0.024776935	24.77693534	7.43	1318.05
315	0.005277798	0.273195114	3.278341369	0.024266101	24.26610068	7.28	1325.33
320	0.005163876	0.267298123	3.207577473	0.02374231	23.74231025	7.12	1332.45
325	0.005086091	0.263271776	3.159261308	0.023384677	23.38467669	7.02	1339.47
330	0.004997218	0.258671426	3.104057109	0.022976058	22.97605827	6.89	1346.36
335	0.004872271	0.252203762	3.026445148	0.022401579	22.40157885	6.72	1353.08
340	0.004791669	0.248031555	2.976378663	0.02203099	22.03098951	6.61	1359.69
345	0.004711067	0.243859348	2.926312178	0.0216604	21.66040017	6.50	1366.19
350	0.004586117	0.237391546	2.848698551	0.021085908	21.08590842	6.33	1372.51
355	0.004497246	0.232791335	2.793496017	0.020677302	20.67730233	6.20	1378.72
360	0.000444422	0.023004664	0.276055969	0.002043351	2.043350945	0.61	1379.33



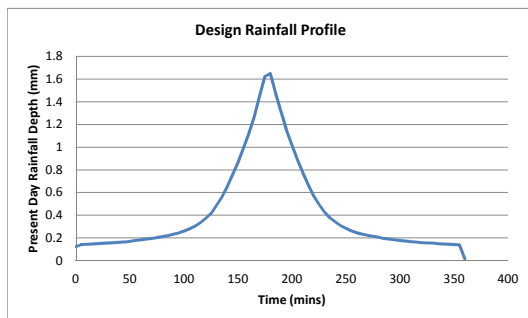
Secondary 6 Embankment to create storage area above town.

Catchment Area (DDF4):	14270.00 m ²
Volume	439.60 m ³
Flow	0.08 m ³ /s

Design Rainfall Profile DDF 4

100years 360 Min

Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.005897908	5.897908135	1.77	
5	0.004583334	0.141192274	1.694307286	0.006716046	6.716045827	2.01	3.78
10	0.004686111	0.144358391	1.732300692	0.006866647	6.866647466	2.06	5.84
15	0.004763887	0.146754329	1.76105195	0.006980614	6.980614257	2.09	7.94
20	0.004861112	0.149749396	1.796992757	0.00712308	7.123079621	2.14	10.08
25	0.004980555	0.153428911	1.841146934	0.007298102	7.298101874	2.19	12.26
30	0.005058334	0.155824932	1.869899183	0.007412073	7.412072594	2.22	14.49
35	0.00514444	0.158477486	1.901729835	0.007538246	7.538245763	2.26	16.75
40	0.005269449	0.162328464	1.947941567	0.007721424	7.721423935	2.32	19.07
45	0.005352775	0.164895369	1.978744433	0.007843523	7.843523073	2.35	21.42
50	0.005544445	0.170799855	2.04959826	0.00812438	8.12437977	2.44	23.86
55	0.005747224	0.177046606	2.124559268	0.008421517	8.421516876	2.53	26.38
60	0.005927781	0.182608744	2.191304923	0.008686089	8.686089236	2.61	28.99
65	0.00613055	0.188855164	2.266261966	0.008983211	8.983210627	2.69	31.68
70	0.006319447	0.194674248	2.33609098	0.009260005	9.260005079	2.78	34.46
75	0.006616663	0.20383017	2.445962035	0.009695522	9.695521732	2.91	37.37
80	0.006897222	0.212472941	2.549675291	0.01010663	10.10662956	3.03	40.40
85	0.007169442	0.220858848	2.65030618	0.010505519	10.50551922	3.15	43.55
90	0.007522224	0.231726508	2.780718095	0.011022458	11.02245756	3.31	46.86
95	0.007905558	0.243535314	2.922423766	0.011584163	11.5841631	3.48	50.34
100	0.008388888	0.258424588	3.101095058	0.012292396	12.29239624	3.69	54.02
105	0.009038889	0.278448252	3.341379018	0.013244855	13.24485516	3.97	58.00
110	0.009766669	0.300867936	3.610415228	0.014311285	14.31128481	4.29	62.29
115	0.010833329	0.333727035	4.004724421	0.015874283	15.87428264	4.76	67.05
120	0.012074993	0.371977222	4.463726669	0.017693717	17.69371655	5.31	72.36
125	0.013477777	0.415190584	4.982287006	0.019749232	19.7492321	5.92	78.29
130	0.01565556	0.482278669	5.787344026	0.022940389	22.94038868	6.88	85.17
135	0.018058345	0.55629787	6.675574435	0.026461235	26.46123533	7.94	93.11
140	0.020961119	0.645719494	7.748633932	0.030714724	30.71472395	9.21	102.32
145	0.024561118	0.756619574	9.079434891	0.035989871	35.98987108	10.80	113.12
150	0.028000015	0.862556811	10.35068173	0.041028952	41.02895229	12.31	125.43
155	0.032116631	0.989371556	11.87245867	0.047061107	47.06110701	14.12	139.54
160	0.036388911	1.120981646	13.45177976	0.05332136	53.32136032	16.00	155.54
165	0.041183274	1.268674809	15.22409771	0.060346632	60.34663177	18.10	173.65
170	0.04689447	1.444611531	17.33533838	0.068715355	68.71535518	20.61	194.26
175	0.052650006	1.621914175	19.4629701	0.077149051	77.14905093	23.14	217.40
180	0.053594459	1.651008606	19.81210328	0.078532976	78.53297605	23.56	240.96
185	0.047805573	1.472678589	17.67214307	0.070050412	70.05041157	21.02	261.98
190	0.042461136	1.308040084	15.69648101	0.062219107	62.21910666	18.67	280.65
195	0.037199995	1.145967575	13.7516109	0.054509858	54.50985767	16.35	297.00
200	0.032949952	1.015042511	12.18051013	0.048282189	48.28218875	14.48	311.48
205	0.028888919	0.889939999	10.67927999	0.042331479	42.33147929	12.70	324.18
210	0.025061063	0.772020677	9.264248123	0.03672245	36.7224502	11.02	335.20
215	0.021772251	0.67070691	8.048482919	0.031903292	31.90329201	9.57	344.77
220	0.018552775	0.571529079	6.858348942	0.027185733	27.18573317	8.16	352.93
225	0.016108339	0.496226797	5.954721561	0.023603855	23.60385463	7.08	360.01
230	0.013913924	0.428626553	5.143518636	0.020388336	20.38833637	6.12	366.12
235	0.012269456	0.37796777	4.535613238	0.017978667	17.97866692	5.39	371.52
240	0.011099976	0.341941232	4.103294781	0.016265005	16.26500459	4.88	376.40
245	0.009944458	0.306344838	3.676138052	0.014571803	14.57180278	4.37	380.77
250	0.00916666	0.2823843	3.388611599	0.01343208	13.43207987	4.03	384.80
255	0.008530533	0.262788055	3.153456659	0.012499952	12.49995181	3.75	388.55
260	0.007969432	0.245503008	2.946036092	0.01167776	11.67775973	3.50	392.05
265	0.007605556	0.234293579	2.811522943	0.011444565	11.44456456	3.34	395.39
270	0.007225016	0.222570834	2.670850014	0.010586953	10.58695269	3.18	398.57
275	0.006955584	0.214270824	2.571249885	0.010192149	10.19214885	3.06	401.63
280	0.00688609	0.205968913	2.47162696	0.009797255	9.797254644	2.94	404.57
285	0.006358347	0.195872589	2.350471069	0.009317006	9.317006154	2.80	407.36
290	0.006169396	0.190051853	2.280622233	0.009040133	9.040133128	2.71	410.07
295	0.005972236	0.183978217	2.207738602	0.008751231	8.751230515	2.63	412.70
300	0.005775014	0.177902681	2.134832176	0.008462238	8.462237542	2.54	415.24
305	0.005591637	0.172253656	2.067043868	0.008193532	8.193532222	2.46	417.70
310	0.005388903	0.166008309	1.992099709	0.007896462	7.896461903	2.37	420.07
315	0.005277798	0.162585658	1.9510279	0.007733658	7.733657814	2.32	422.39
320	0.005163876	0.159076202	1.908914428	0.007566725	7.566724693	2.27	424.66
325	0.005086091	0.156680016	1.880160197	0.007452746	7.452746116	2.24	426.89
330	0.004997218	0.153942226	1.847306714	0.007322519	7.322518559	2.20	429.09
335	0.004872271	0.150093148	1.801117778	0.007139431	7.139430746	2.14	431.23
340	0.004791669	0.147610157	1.771321885	0.007021323	7.021323137	2.11	433.34
345	0.004711067	0.145127166	1.741525992	0.006903216	6.903215528	2.07	435.41
350	0.004586117	0.141278005	1.695336064	0.006720124	6.720123786	2.02	437.42
355	0.004497246	0.138540298	1.662483572	0.0065899	6.589900158	1.98	439.40
360	0.000444422	0.013690686	0.164288229	0.00065122	0.651220285	0.20	439.60



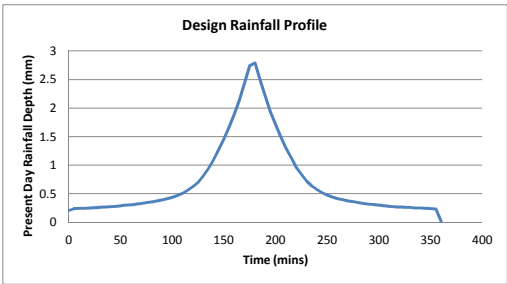
Drainage 8 New pipe in Castle Road (South) + D3 + D4. Discharge to D9.

Catchment Area (DDF3):	13000.00 m ²
Volume	675.79 m ³
Flow	0.12 m ³ /s

Design Rainfall Profile DDF3

100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.009066819	9.066819037	2.72	
5	0.004583334	0.238258552	2.859102619	0.010324537	10.32453724	3.10	5.82
10	0.004686111	0.243601298	2.923215574	0.010556056	10.55605624	3.17	8.98
15	0.004763887	0.247644386	2.971732627	0.010731257	10.73125671	3.22	12.20
20	0.004861112	0.252698489	3.03238187	0.010950268	10.95026786	3.29	15.49
25	0.004980555	0.258907581	3.106890978	0.011219329	11.21932853	3.37	18.85
30	0.005058334	0.262950809	3.155409703	0.011394535	11.39453504	3.42	22.27
35	0.00514444	0.26742693	3.20912316	0.0115885	11.5885003	3.48	25.75
40	0.005269449	0.273925362	3.287104342	0.011870099	11.87009901	3.56	29.31
45	0.005352775	0.278256953	3.339083434	0.012057801	12.05780129	3.62	32.93
50	0.005544445	0.28822063	3.458647556	0.012489561	12.48956062	3.75	36.67
55	0.005747224	0.29876187	3.585142445	0.012946348	12.94634772	3.88	40.56
60	0.005927781	0.308147844	3.697774126	0.013353073	13.35307323	4.01	44.56
65	0.00613055	0.318688527	3.824262326	0.013809836	13.80983618	4.14	48.71
70	0.006319447	0.328508092	3.9420971	0.014235351	14.23535064	4.27	52.98
75	0.006616663	0.343958488	4.127501851	0.014904868	14.90486779	4.47	57.45
80	0.006897222	0.358542956	4.302515466	0.015536861	15.53686141	4.66	62.11
85	0.007169442	0.372693972	4.47232766	0.016150072	16.15007211	4.85	66.96
90	0.007522224	0.391032885	4.692394616	0.016944758	16.94475834	5.08	72.04
95	0.007905558	0.41095996	4.931519514	0.017808265	17.80826491	5.34	77.38
100	0.008388888	0.43608525	5.233023002	0.018897028	18.89702751	5.67	83.05
105	0.009038889	0.469874698	5.638496382	0.020361237	20.36123693	6.11	89.16
110	0.009766669	0.507707374	6.092488487	0.022000653	22.00065287	6.60	95.76
115	0.010833329	0.56315631	6.757875725	0.02440344	24.40344012	7.32	103.08
120	0.012074993	0.627702578	7.532430932	0.027200445	27.20044503	8.16	111.24
125	0.01347777	0.700624081	8.407488974	0.030360377	30.36037685	9.11	120.35
130	0.01565556	0.813833604	9.76600325	0.035266123	35.26612285	10.58	130.93
135	0.018058345	0.938739217	11.26487061	0.040678699	40.67869942	12.20	143.13
140	0.020961119	1.089636049	13.07563259	0.047217562	47.21756213	14.17	157.30
145	0.024561118	1.276777255	15.32132706	0.055327014	55.32701439	16.60	173.90
150	0.028000015	1.455543783	17.46652539	0.063073564	63.07356391	18.92	192.82
155	0.032116631	1.669540602	20.03448723	0.072346759	72.34675943	21.70	214.52
160	0.036388911	1.891629451	22.69955341	0.08197061	81.97060954	24.59	239.11
165	0.041183274	2.140858096	25.69029715	0.0927770517	92.77051748	27.83	266.94
170	0.04689447	2.437747064	29.25296477	0.105635706	105.6357061	31.69	298.63
175	0.052650006	2.736940993	32.84329191	0.118600776	118.6007764	35.58	334.21
180	0.053594459	2.786037143	33.43244571	0.120728276	120.7282762	36.22	370.43
185	0.047805573	2.485109547	29.82131456	0.107688808	107.68880803	32.31	402.74
190	0.042461136	2.207286045	26.48743255	0.095649062	95.64906197	28.69	431.43
195	0.037199995	1.933792602	23.5051123	0.083797679	83.79767943	25.14	456.57
200	0.032949952	1.712859718	20.55431662	0.074223921	74.22392111	22.27	478.84
205	0.028888919	1.501752252	18.02102702	0.065075931	65.07593091	19.52	498.36
210	0.025061063	1.302766244	15.63319493	0.056453204	56.4532039	16.94	515.30
215	0.021772251	1.131801709	13.58162051	0.049044741	49.04474074	14.71	530.01
220	0.018552775	0.964441515	11.57329817	0.041792466	41.79246563	12.54	542.55
225	0.016108339	0.837370733	10.0484488	0.036286065	36.2860651	10.89	553.44
230	0.013913924	0.723296955	8.679563455	0.031342868	31.34286803	9.40	562.84
235	0.012269456	0.637811482	7.65373778	0.027638498	27.63849754	8.29	571.13
240	0.011099976	0.577017569	6.924210827	0.025004095	25.00409465	7.50	578.63
245	0.009944458	0.516949514	6.203394165	0.022401146	22.40114559	6.72	585.35
250	0.00916666	0.476516685	5.718200221	0.020649056	20.64905635	6.19	591.55
255	0.008530533	0.443448495	5.32138194	0.019216101	19.21610145	5.76	597.31
260	0.007969432	0.414280395	4.971364744	0.01795215	17.95215046	5.39	602.70
265	0.007605556	0.395364754	4.744377054	0.017132473	17.13247269	5.14	607.84
270	0.007225016	0.375582907	4.506994883	0.016275259	16.2752593	4.88	612.72
275	0.006955584	0.361576839	4.338922071	0.01566833	15.6683297	4.70	617.42
280	0.00668609	0.347567566	4.170810792	0.015061261	15.06126119	4.52	621.94
285	0.006358347	0.330530263	3.966363152	0.014322978	14.32297805	4.30	626.24
290	0.006169396	0.320707911	3.848494929	0.013897343	13.8973428	4.17	630.40
295	0.005972236	0.310458797	3.725505563	0.013453215	13.45321453	4.04	634.44
300	0.005775014	0.300206477	3.602477729	0.013008947	13.00894736	3.90	638.34
305	0.005591637	0.290673883	3.488086597	0.012595868	12.59586827	3.78	642.12
310	0.005388903	0.280135012	3.36162014	0.012139184	12.13918384	3.64	645.76
315	0.005277798	0.274359371	3.292312453	0.011888906	11.88890608	3.57	649.33
320	0.005163876	0.268437249	3.221246988	0.011632281	11.63228079	3.49	652.82
325	0.005086091	0.264393743	3.172724917	0.011457062	11.4570622	3.44	656.26
330	0.004997218	0.259773788	3.117285458	0.011256864	11.25686415	3.38	659.63
335	0.004872271	0.253278562	3.039342743	0.010975404	10.97540435	3.29	662.93
340	0.004791669	0.249088574	2.989062893	0.010793838	10.79383823	3.24	666.17
345	0.004711067	0.244898587	2.938783044	0.010612272	10.6122721	3.18	669.35
350	0.004586117	0.238403221	2.860838656	0.010330806	10.33080626	3.10	672.45
355	0.004497246	0.233783406	2.80540087	0.010130614	10.13061425	3.04	675.49
360	0.000444422	0.023102701	0.277232418	0.001001117	1.001117064	0.30	675.79

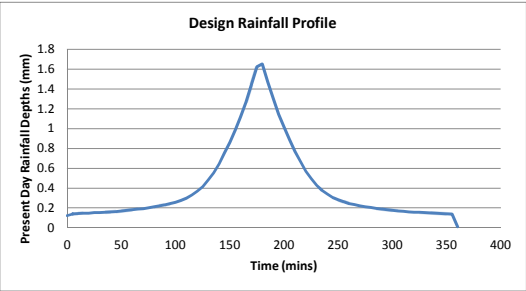


Drainage 8 New pipe in Castle Road (South) + D3 + D4. Discharge to D9.

Catchment Area (DDF4):	50694.00 m ²
Volume	1561.66 m ³
Flow	0.28 m ³ /s

Design Rainfall Profile DDF4
100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.020952246	20.95224632	6.29	
5	0.004583334	0.141192274	1.694307286	0.02385867	23.85867044	7.16	13.44
10	0.004686111	0.144358391	1.732300692	0.024393681	24.39368091	7.32	20.76
15	0.004763887	0.146754329	1.76105195	0.024798547	24.79854654	7.44	28.20
20	0.004861112	0.149749396	1.796992757	0.025304653	25.304653	7.59	35.79
25	0.004980555	0.153428911	1.841146934	0.025926417	25.92641741	7.78	43.57
30	0.005058334	0.155824932	1.869899183	0.026331297	26.33129699	7.90	51.47
35	0.00514444	0.158477486	1.901729835	0.026779526	26.77952563	8.03	59.50
40	0.005269449	0.162328464	1.947941567	0.027430264	27.43026384	8.23	67.73
45	0.005352775	0.164895369	1.978744433	0.02786402	27.86401953	8.36	76.09
50	0.005544445	0.170799855	2.04959826	0.02886176	28.8617595	8.66	84.75
55	0.005747224	0.177046606	2.124559268	0.029917335	29.91733543	8.98	93.73
60	0.005927781	0.182608744	2.191304923	0.030857225	30.85722549	9.26	102.98
65	0.00613055	0.188855164	2.266261966	0.031912746	31.91274559	9.57	112.56
70	0.006319447	0.194674248	2.33609098	0.032896054	32.89605448	9.87	122.43
75	0.006616663	0.20383017	2.445962035	0.034443222	34.44322205	10.33	132.76
80	0.006897222	0.212472941	2.549675291	0.035903678	35.90367756	10.77	143.53
85	0.007169442	0.220858848	2.65030618	0.037320728	37.32072819	11.20	154.73
90	0.007522224	0.231726508	2.780718095	0.039157145	39.15714531	11.75	166.47
95	0.007905558	0.243535314	2.922423766	0.041152597	41.15259734	12.35	178.82
100	0.008388888	0.258424588	3.101095058	0.043668587	43.6685869	13.10	191.92
105	0.009038889	0.278448252	3.341379018	0.047052186	47.05218554	14.12	206.03
110	0.009766669	0.300867936	3.610415228	0.050840664	50.84066377	15.25	221.29
115	0.010833329	0.333727035	4.004724421	0.056393194	56.39319434	16.92	238.20
120	0.012074993	0.371977222	4.463726669	0.062856711	62.85671105	18.86	257.06
125	0.01347777	0.415190584	4.982287006	0.070158905	70.15890485	21.05	278.11
130	0.01565556	0.482278669	5.787344026	0.081495449	81.49544947	24.45	302.56
135	0.018058345	0.55629787	6.675574435	0.094003214	94.003214	28.20	330.76
140	0.020961119	0.645719494	7.748633932	0.10911368	109.1136802	32.73	363.49
145	0.024561118	0.756619574	9.079434891	0.127853576	127.8535757	38.36	401.85
150	0.028000015	0.862556811	10.35068173	0.14575485	145.7548499	43.73	445.58
155	0.032116631	0.989371556	11.87245867	0.167184006	167.1840055	50.16	495.73
160	0.036388911	1.120981646	13.45177976	0.189423479	189.4234786	56.83	552.56
165	0.041183274	1.268674809	15.22409771	0.214380669	214.3806693	64.31	616.87
170	0.04689447	1.444611531	17.33533838	0.244110457	244.1104566	73.23	690.11
175	0.052650006	1.621914175	19.4629701	0.274071057	274.0710573	82.22	772.33
180	0.053594459	1.651008606	19.81210328	0.278987434	278.9874343	83.70	856.02
185	0.047805573	1.472678589	17.67214307	0.248853228	248.853228	74.66	930.68
190	0.042461136	1.308040084	15.69648101	0.221032613	221.0326134	66.31	996.99
195	0.037199995	1.145967575	13.7516109	0.193645601	193.6456009	58.09	1055.08
200	0.032949952	1.015042511	12.18051013	0.171521883	171.5218834	51.46	1106.54
205	0.028888919	0.889939999	10.67927999	0.150382061	150.382061	45.11	1151.65
210	0.025061063	0.772020677	9.264248123	0.130456054	130.456054	39.14	1190.79
215	0.021772251	0.67070691	8.048482919	0.113336054	113.3360536	34.00	1224.79
220	0.018552775	0.571529079	6.858348942	0.096576984	96.57698369	28.97	1253.76
225	0.016108339	0.496226797	5.954721561	0.083852404	83.85240412	25.16	1278.92
230	0.013913924	0.428626553	5.143518636	0.072429315	72.42931492	21.73	1300.65
235	0.012269456	0.37796777	4.535613238	0.063868994	63.86899375	19.16	1319.81
240	0.011099976	0.341941232	4.103294781	0.057781229	57.78122935	17.33	1337.14
245	0.009944458	0.306344838	3.676138052	0.051766151	51.76615067	15.53	1352.67
250	0.00916666	0.2823843	3.388611599	0.047717299	47.717299	14.32	1366.99
255	0.008530533	0.262788055	3.153456659	0.044405926	44.40592552	13.32	1380.31
260	0.007969432	0.245503008	2.946036092	0.041485098	41.48509824	12.45	1392.76
265	0.007605556	0.234293579	2.811522943	0.039590929	39.59092891	11.88	1404.63
270	0.007225016	0.222570834	2.670850014	0.03761002	37.61001961	11.28	1415.92
275	0.006955584	0.214270824	2.571249885	0.036207484	36.20748379	10.86	1426.78
280	0.00668609	0.205968913	2.47162696	0.034804627	34.80462698	10.44	1437.22
285	0.006358347	0.195872589	2.350471069	0.03309855	33.0985501	9.93	1447.15
290	0.006169396	0.190051853	2.280622233	0.032114962	32.11496207	9.63	1456.78
295	0.005972236	0.183978217	2.207738602	0.031088639	31.08863908	9.33	1466.11
300	0.005775014	0.177902681	2.134832176	0.030061995	30.06199509	9.02	1475.13
305	0.005591637	0.172253656	2.067043868	0.029107423	29.10742274	8.73	1483.86
310	0.005388903	0.166008309	1.992099709	0.028052084	28.05208407	8.42	1492.28
315	0.005277798	0.162585658	1.9510279	0.027473725	27.47372454	8.24	1500.52
320	0.005163876	0.159076202	1.908914428	0.026880697	26.88069668	8.06	1508.58
325	0.005086091	0.156680016	1.880160197	0.026475789	26.47578918	7.94	1516.53
330	0.004997218	0.153942226	1.847306714	0.026013157	26.01315738	7.80	1524.33
335	0.004872271	0.150093148	1.801117778	0.02536274	25.36274017	7.61	1531.94
340	0.004791669	0.147610157	1.771321885	0.024943164	24.94316434	7.48	1539.42
345	0.004711067	0.145127166	1.741525992	0.024523589	24.5235885	7.36	1546.78
350	0.004586117	0.141278005	1.695336064	0.023873157	23.87315734	7.16	1553.94
355	0.004497246	0.138540298	1.662483572	0.023410539	23.4105395	7.02	1560.96
360	0.000444422	0.013690686	0.164288229	0.002313452	2.313452076	0.69	1561.66

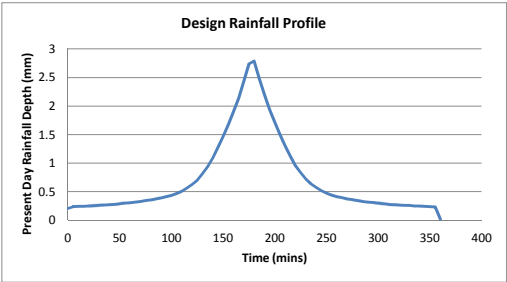


Secondary 10 Storage ditch.

Catchment Area:	8503.00 m ²
Volume	442.02 m ³
Flow	0.08 m ³ /s

Design Rainfall Profile DDF3
100years 360 Min

Time (mins)	Percentage	Present Day Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.209234285	2.510811426	0.005930397	5.930397098	1.78	
5	0.004583334	0.238258552	2.859102619	0.006753042	6.753041547	2.03	3.81
10	0.004686111	0.243601298	2.923215574	0.006904473	6.904472785	2.07	5.88
15	0.004763887	0.247644386	2.971732627	0.007019067	7.019067368	2.11	7.98
20	0.004861112	0.252698489	3.03238187	0.007162318	7.162317511	2.15	10.13
25	0.004980555	0.258907581	3.106890978	0.007338304	7.338303884	2.20	12.33
30	0.005058334	0.262950809	3.155409703	0.007452902	7.452902418	2.24	14.57
35	0.00514444	0.26742693	3.20912316	0.007579771	7.579770619	2.27	16.84
40	0.005269449	0.273925362	3.287104342	0.007763958	7.763957839	2.33	19.17
45	0.005352775	0.278256953	3.339083434	0.00788673	7.886729567	2.37	21.54
50	0.005544445	0.28822063	3.458647556	0.008169133	8.169133379	2.45	23.99
55	0.005747224	0.29876187	3.585142445	0.008467907	8.467907282	2.54	26.53
60	0.005927781	0.308147844	3.697774126	0.008733937	8.733937053	2.62	29.15
65	0.00613055	0.318688527	3.824262326	0.009032695	9.032695154	2.71	31.86
70	0.006319447	0.328508092	3.9420971	0.009311014	9.311014344	2.79	34.65
75	0.006616663	0.343958488	4.127501851	0.00974893	9.748930066	2.92	37.58
80	0.006897222	0.358542956	4.302515466	0.010162303	10.1623025	3.05	40.63
85	0.007169442	0.372693972	4.47232766	0.010563389	10.56338947	3.17	43.79
90	0.007522224	0.391032885	4.692394616	0.011083175	11.0831754	3.32	47.12
95	0.007905558	0.41095996	4.931519514	0.011647975	11.64797512	3.49	50.61
100	0.008388888	0.43608525	5.233023002	0.01236011	12.36010961	3.71	54.32
105	0.009038889	0.469874698	5.638496382	0.013317815	13.3178152	4.00	58.32
110	0.009766669	0.507707374	6.092488487	0.014390119	14.39011933	4.32	62.63
115	0.010833329	0.56315631	6.757875725	0.015961727	15.96172703	4.79	67.42
120	0.012074993	0.627702578	7.532430932	0.017791183	17.79118339	5.34	72.76
125	0.01347777	0.700624081	8.407488974	0.019858022	19.85802187	5.96	78.72
130	0.01565556	0.813833604	9.76600325	0.02306757	23.0675712	6.92	85.64
135	0.018058345	0.938739217	11.26487061	0.026606999	26.60699855	7.98	93.62
140	0.020961119	1.089636049	13.07563259	0.030883918	30.88391775	9.27	102.88
145	0.024561118	1.276777255	15.32132706	0.036188123	36.18812334	10.86	113.74
150	0.028000015	1.455543783	17.46652539	0.041254963	41.25496261	12.38	126.12
155	0.032116631	1.669540602	20.03448723	0.047320346	47.3203458	14.20	140.31
160	0.036388911	1.891629451	22.69955341	0.053615084	53.61508407	16.08	156.40
165	0.041183274	2.140858096	25.69029715	0.060679055	60.67905463	18.20	174.60
170	0.04689447	2.437747064	29.25296477	0.069093878	69.09387762	20.73	195.33
175	0.052650006	2.736940993	32.84329191	0.077574031	77.57403087	23.27	218.60
180	0.053594459	2.786037143	33.43244571	0.078965579	78.96557942	23.69	242.29
185	0.047805573	2.485109547	29.82131456	0.070436288	70.43628825	21.13	263.42
190	0.042461136	2.207286045	26.48743255	0.062561844	62.56184415	18.77	282.19
195	0.037199995	1.933792602	23.20551123	0.054810128	54.81012832	16.44	298.63
200	0.032949952	1.712859718	20.55431662	0.048548154	48.54815394	14.56	313.20
205	0.028888919	1.501752252	18.02102702	0.042564665	42.56466466	12.77	325.97
210	0.025061063	1.302766244	15.63319493	0.036924738	36.92473791	11.08	337.05
215	0.021772251	1.131801709	13.58162051	0.032079033	32.07903311	9.62	346.67
220	0.018552775	0.964441515	11.57329817	0.027335487	27.33548733	8.20	354.87
225	0.016108339	0.837370733	10.04844488	0.023733878	23.73387781	7.12	361.99
230	0.013913924	0.723296955	8.679563455	0.020500647	20.50064668	6.15	368.14
235	0.012269456	0.637811482	7.65373778	0.018077703	18.07770343	5.42	373.56
240	0.011099976	0.577017569	6.924210827	0.016354601	16.3546013	4.91	378.47
245	0.009944458	0.516949514	6.203394165	0.014652072	14.65207238	4.40	382.87
250	0.00916666	0.476516685	5.718200221	0.013506071	13.50607124	4.05	386.92
255	0.008530533	0.443448495	5.32138194	0.012568809	12.56880851	3.77	390.69
260	0.007969432	0.414280395	4.971364744	0.011742087	11.74208734	3.52	394.21
265	0.007605556	0.395364754	4.744377054	0.011205955	11.20595502	3.36	397.57
270	0.007225016	0.375582907	4.506994883	0.010645272	10.64527152	3.19	400.77
275	0.006955584	0.361576839	4.338922071	0.010248293	10.24829288	3.07	403.84
280	0.00668609	0.347567566	4.170810792	0.009851223	9.85122338	2.96	406.80
285	0.006358347	0.330530263	3.966363152	0.009368329	9.368329413	2.81	409.61
290	0.006169396	0.320707911	3.848494929	0.009089931	9.089931216	2.73	412.33
295	0.005972236	0.310458797	3.725505563	0.008799437	8.799437166	2.64	414.97
300	0.005775014	0.300206477	3.602477729	0.008508852	8.508852259	2.55	417.53
305	0.005591637	0.290673883	3.488086597	0.008238667	8.23866676	2.47	420.00
310	0.005388903	0.280135012	3.36162014	0.00793996	7.939960013	2.38	422.38
315	0.005277798	0.274359371	3.292312453	0.007776259	7.776259109	2.33	424.71
320	0.005163876	0.268437249	3.221246988	0.007608406	7.608406427	2.28	426.99
325	0.005086091	0.264393743	3.172724917	0.0074938	7.493799992	2.25	429.24
330	0.004997218	0.259773788	3.117285458	0.007362855	7.36285507	2.21	431.45
335	0.004872271	0.253278562	3.039342743	0.007178759	7.178758707	2.15	433.61
340	0.004791669	0.249088574	2.989062893	0.00706	7.060000495	2.12	435.72
345	0.004711067	0.244898587	2.938783044	0.006941242	6.941242283	2.08	437.81
350	0.004586117	0.238403221	2.860838656	0.006757142	6.757141971	2.03	439.83
355	0.004497246	0.233783406	2.80540087	0.006626201	6.626200999	1.99	441.82
360	0.000444422	0.023102701	0.277232418	0.000654808	0.654807569	0.20	442.02

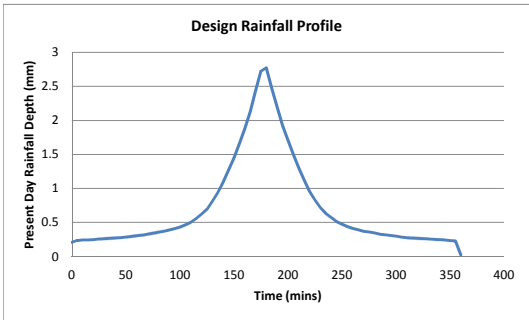


Secondary 12 Embankment to create storage area beside Irish Row.

Catchment Area (DDF6):	2642.00 m ²
Volume	136.76 m ³
Flow	0.02 m ³ /s

Design Rainfall Profile DDF 6

100years	360 Min							
	Time (mins)	Percentage	Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
	0	0.004025	0.20834639	2.500156678	0.001834837	1.834837206	0.55	
	5	0.004583334	0.23724749	2.846969881	0.00208936	2.089359563	0.63	1.18
	10	0.004686111	0.242567564	2.91081077	0.002136212	2.136211681	0.64	1.82
	15	0.004763887	0.246593495	2.959121938	0.002171667	2.171666711	0.65	2.47
	20	0.004861112	0.251626151	3.019513813	0.002215988	2.215987637	0.66	3.13
	25	0.004980555	0.257808895	3.093706738	0.002270437	2.270437	0.68	3.82
	30	0.005058334	0.261834964	3.142019572	0.002305893	2.305893252	0.69	4.51
	35	0.00514444	0.266292091	3.195505093	0.002345146	2.345145682	0.70	5.21
	40	0.005269449	0.272762947	3.273155358	0.002402132	2.402132349	0.72	5.93
	45	0.005352775	0.277076156	3.324913875	0.002440117	2.440117349	0.73	6.66
	50	0.005544445	0.286997552	3.44397062	0.002527492	2.527491772	0.76	7.42
	55	0.005747224	0.29749406	3.569928723	0.002619931	2.619931024	0.79	8.21
	60	0.005927781	0.306840204	3.682082445	0.002702239	2.702239394	0.81	9.02
	65	0.00613055	0.317336157	3.808033886	0.002794674	2.794673758	0.84	9.86
	70	0.006319447	0.327114052	3.925368623	0.002880784	2.880784417	0.86	10.72
	75	0.006616663	0.342498883	4.1099866	0.003016273	3.016273499	0.90	11.63
	80	0.006897222	0.357021461	4.284257537	0.003144169	3.144169003	0.94	12.57
	85	0.007169442	0.371112427	4.453349125	0.003268263	3.268263441	0.98	13.55
	90	0.007522224	0.389373518	4.672482216	0.003429083	3.429082782	1.03	14.58
	95	0.007905558	0.409216031	4.910592376	0.003603829	3.603829183	1.08	15.66
	100	0.008388888	0.434234702	5.21081642	0.00382416	3.824160272	1.15	16.81
	105	0.009038889	0.467880763	5.614569154	0.00412047	4.120469918	1.24	18.04
	110	0.009766669	0.505552893	6.066634722	0.004452236	4.452235815	1.34	19.38
	115	0.010833329	0.56076653	6.729198358	0.004938484	4.938483906	1.48	20.86
	120	0.012074993	0.625038892	7.500466703	0.005504509	5.504509174	1.65	22.51
	125	0.01347777	0.697650949	8.371811394	0.006143979	6.143979362	1.84	24.35
	130	0.01565556	0.810380062	9.72456075	0.007136747	7.136747084	2.14	26.50
	135	0.018058345	0.934755633	11.21706759	0.008232081	8.232081273	2.47	28.97
	140	0.020961119	1.085012127	13.02014552	0.00955534	9.555340129	2.87	31.83
	145	0.024561118	1.27135919	15.25631028	0.011196437	11.1964366	3.36	35.19
	150	0.028000015	1.449367113	17.39240536	0.012764093	12.76409304	3.83	39.02
	155	0.032116631	1.662455827	19.94946992	0.014640694	14.64069432	4.39	43.41
	160	0.036388911	1.883602231	22.60322677	0.016588257	16.58825698	4.98	48.39
	165	0.041183274	2.131773262	25.58127915	0.018773817	18.77381653	5.63	54.02
	170	0.04689447	2.427402368	29.12882842	0.021377324	21.37732353	6.41	60.43
	175	0.052650006	2.725326653	32.70391984	0.024001043	24.00104339	7.20	67.63
	180	0.053594459	2.774214462	33.29057354	0.024431582	24.43158202	7.33	74.96
	185	0.047805573	2.474563866	29.69476639	0.021792659	21.79265911	6.54	81.50
	190	0.042461136	2.197919322	26.37503186	0.019356343	19.35634283	5.81	87.31
	195	0.037199995	1.925586461	23.10703754	0.016957998	16.9579981	5.09	92.40
	200	0.032949952	1.705591116	20.46709339	0.015020572	15.02057243	4.51	96.90
	205	0.028888919	1.495379495	17.94455393	0.013169309	13.16930875	3.95	100.85
	210	0.025061063	1.297237893	15.56685472	0.011424342	11.42434171	3.43	104.28
	215	0.021772251	1.126998855	13.52398626	0.009925103	9.925103249	2.98	107.26
	220	0.018552775	0.960348861	11.52418633	0.008457472	8.457472303	2.54	109.80
	225	0.016108339	0.83381731	10.00580773	0.007343151	7.343151114	2.20	112.00
	230	0.013913924	0.720227609	8.642731314	0.006342804	6.342804481	1.90	113.90
	235	0.012269456	0.635104898	7.62125878	0.005593157	5.593157138	1.68	115.58
	240	0.011099976	0.574568967	6.894827609	0.005060037	5.060037373	1.52	117.10
	245	0.009944458	0.514755814	6.177069766	0.004533283	4.533282867	1.36	118.46
	250	0.009166666	0.474494564	5.693934766	0.004178715	4.178715459	1.25	119.71
	255	0.008530533	0.4415667	5.298800402	0.003888731	3.888730739	1.17	120.88
	260	0.007969432	0.412522377	4.950268521	0.003632947	3.632947064	1.09	121.97
	265	0.007605556	0.393687005	4.724244064	0.00346707	3.467070227	1.04	123.01
	270	0.007225016	0.373989103	4.487869236	0.003293597	3.293597367	0.99	124.00
	275	0.006955584	0.360042471	4.320509649	0.003170774	3.170774026	0.95	124.95
	280	0.00668609	0.346092647	4.153111758	0.003047923	3.047922574	0.91	125.86
	285	0.006358347	0.329127642	3.949531702	0.002898517	2.898517432	0.87	126.73
	290	0.006169396	0.319346971	3.832163657	0.002812382	2.812382328	0.84	127.57
	295	0.005972236	0.30914135	3.709696202	0.002722505	2.722504824	0.82	128.39
	300	0.005775014	0.298932537	3.587190444	0.002632599	2.632599209	0.79	129.18
	305	0.005591637	0.289440395	3.473284736	0.002549005	2.549005076	0.76	129.95
	310	0.005388903	0.278946245	3.347354945	0.002456587	2.456586601	0.74	130.68
	315	0.005277798	0.273195114	3.278341369	0.002405938	2.405938304	0.72	131.40
	320	0.005163876	0.267298123	3.207577473	0.002354005	2.354005467	0.71	132.11
	325	0.005086091	0.263271776	3.159261308	0.002318547	2.318546771	0.70	132.81
	330	0.004997218	0.258671426	3.104057109	0.002278033	2.278033023	0.68	133.49
	335	0.004872721	0.252203762	3.026445148	0.002221074	2.221074467	0.67	134.16
	340	0.004791669	0.248031555	2.976378663	0.002184331	2.18433123	0.66	134.81
	345	0.004711067	0.243859348	2.926312178	0.002147588	2.147587993	0.64	135.46
	350	0.004586117	0.237391546	2.848698551	0.002090628	2.090628215	0.63	136.08
	355	0.004497246	0.232791335	2.793496017	0.002050116	2.050115688	0.62	136.70
	360	0.000444422	0.023004664	0.276055969	0.000202594	0.202594408	0.06	136.76

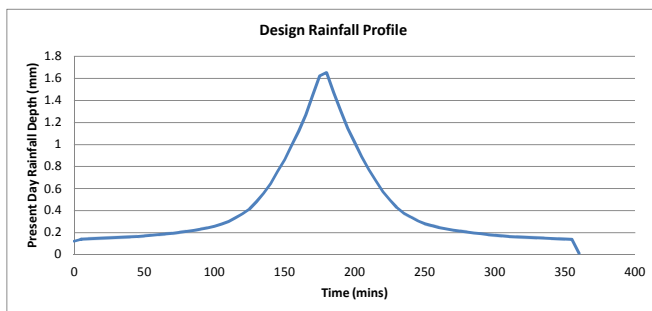


Secondary 12 Embankment to create storage area beside Irish Row.

Catchment Area (DDF4):	23160.00 m ²
Volume	713.46 m ³
Flow	0.13 m ³ /s

Design Rainfall Profile DDF 4
100years 360 Min

Time (mins)	Percentage	ay Rainfall Depth (mm)	Intensity (mm/hr)	Flow (m ³ /s)	Flow (l/s)	Volume (m ³)	Cum. Volume (m ³)
0	0.004025	0.123992463	1.48790955	0.009572218	9.572218108	2.87	
5	0.004583334	0.141192274	1.694307286	0.010900044	10.90004354	3.27	6.14
10	0.004686111	0.144358391	1.732300692	0.011144468	11.14446779	3.34	9.49
15	0.004763887	0.146754329	1.76105195	0.011329434	11.32943421	3.40	12.88
20	0.004861112	0.149749396	1.796992757	0.011560653	11.5606534	3.47	16.35
25	0.004980555	0.153428911	1.841146934	0.011844712	11.84471194	3.55	19.91
30	0.005058334	0.155824932	1.869899183	0.012029685	12.02968474	3.61	23.51
35	0.00514444	0.158477486	1.901729835	0.012234462	12.23446194	3.67	27.18
40	0.005269449	0.162328464	1.947941567	0.012531757	12.53175742	3.76	30.94
45	0.005352775	0.164895369	1.978744433	0.012729923	12.72992252	3.82	34.76
50	0.005544445	0.170799855	2.04959826	0.013185749	13.18574881	3.96	38.72
55	0.005747224	0.177046606	2.124559268	0.013667998	13.66799796	4.10	42.82
60	0.005927781	0.182608744	2.191304923	0.014097395	14.097395	4.23	47.05
65	0.00613055	0.188855164	2.266261966	0.014579619	14.57961865	4.37	51.42
70	0.006319447	0.194674248	2.33609098	0.015028852	15.02885197	4.51	55.93
75	0.006616663	0.20383017	2.445962035	0.015735689	15.73568909	4.72	60.65
80	0.006897222	0.212472941	2.549675291	0.016402911	16.40291104	4.92	65.57
85	0.007169442	0.220858848	2.65030618	0.017050303	17.05030309	5.12	70.69
90	0.007522224	0.231726508	2.780718095	0.017889286	17.88928641	5.37	76.05
95	0.007905558	0.243535314	2.922423766	0.018800926	18.80092623	5.64	81.69
100	0.008388888	0.258424588	3.101095058	0.019950378	19.9503782	5.99	87.68
105	0.009038889	0.278448252	3.341379018	0.021496205	21.49620502	6.45	94.13
110	0.009766669	0.300867936	3.610415228	0.023227005	23.22700463	6.97	101.10
115	0.010833329	0.333727035	4.004724421	0.025763727	25.76372711	7.73	108.83
120	0.012074993	0.371977222	4.463726669	0.028716642	28.71664157	8.61	117.44
125	0.01347777	0.415190584	4.982287006	0.032052713	32.05271307	9.62	127.06
130	0.01565556	0.482278669	5.787344026	0.037231913	37.23191324	11.17	138.23
135	0.018058345	0.55629787	6.675574435	0.042946196	42.94619553	12.88	151.11
140	0.020961119	0.645719494	7.748633932	0.049849545	49.84954496	14.95	166.07
145	0.024561118	0.756619574	9.079434891	0.058411031	58.41103113	17.52	183.59
150	0.028000015	0.862556811	10.35068173	0.066589386	66.58938578	19.98	203.57
155	0.032116631	0.989371556	11.87245867	0.076379484	76.37948412	22.91	226.48
160	0.036388911	1.120981646	13.45177976	0.086539783	86.53978311	25.96	252.44
165	0.041183274	1.268674809	15.22409771	0.097941695	97.94169529	29.38	281.82
170	0.04689447	1.444611531	17.33533838	0.11152401	111.5240102	33.46	315.28
175	0.052650006	1.621914175	19.4629701	0.125211774	125.2117743	37.56	352.84
180	0.053594459	1.651008606	19.81210328	0.127457864	127.4578644	38.24	391.08
185	0.047805573	1.472678589	17.67214307	0.113690787	113.6907871	34.11	425.19
190	0.042461136	1.308040084	15.69648101	0.100980694	100.9806945	30.29	455.48
195	0.037199995	1.145967575	13.7516109	0.088468697	88.46869682	26.54	482.02
200	0.032949952	1.015042511	12.18051013	0.078361282	78.36128181	23.51	505.53
205	0.028888919	0.889939999	10.67927999	0.068703368	68.70336793	20.61	526.14
210	0.025061063	0.772020677	9.264248123	0.059599996	59.59999626	17.88	544.02
215	0.021772251	0.67070691	8.048482919	0.051778573	51.77857344	15.53	559.56
220	0.018552775	0.571529079	6.858348942	0.044122045	44.12204486	13.24	572.79
225	0.016108339	0.496226797	5.954721561	0.038308709	38.30870871	11.49	584.29
230	0.013913924	0.428626553	5.143518636	0.03308997	33.08996989	9.93	594.21
235	0.012269456	0.37796777	4.535613238	0.029179112	29.17911183	8.75	602.97
240	0.011099976	0.341941232	4.103294781	0.026397863	26.39786309	7.92	610.89
245	0.009944458	0.306344838	3.676138052	0.023649821	23.64982147	7.09	617.98
250	0.00916666	0.2823843	3.388611599	0.021800068	21.80006796	6.54	624.52
255	0.008530533	0.262788055	3.153456659	0.020287238	20.28723784	6.09	630.61
260	0.007969432	0.245503008	2.946036092	0.018952832	18.95283219	5.69	636.29
265	0.007605556	0.234293579	2.811522943	0.018087464	18.08746427	5.43	641.72
270	0.007225016	0.222570834	2.670850014	0.017182468	17.18246842	5.15	646.87
275	0.006955584	0.214270824	2.571249885	0.016541708	16.54170759	4.96	651.84
280	0.00668609	0.205968913	2.47162696	0.0159008	15.90080011	4.77	656.61
285	0.006358347	0.195872589	2.350471069	0.015121364	15.12136388	4.54	661.14
290	0.006169396	0.190051853	2.280622233	0.014672003	14.67200303	4.40	665.54
295	0.005972236	0.183978217	2.207738602	0.014203118	14.20311834	4.26	669.81
300	0.005775014	0.177902681	2.134832176	0.013734087	13.734087	4.12	673.93
305	0.005591637	0.172253656	2.067043868	0.013297982	13.29798222	3.99	677.92
310	0.005388903	0.166008309	1.992099709	0.012815841	12.81584146	3.84	681.76
315	0.005277798	0.162585658	1.9510279	0.012551613	12.55161282	3.77	685.53
320	0.005163876	0.159076202	1.908914428	0.012280683	12.28068282	3.68	689.21
325	0.005086091	0.156680016	1.880160197	0.012095697	12.09569727	3.63	692.84
330	0.004997218	0.153942226	1.847306714	0.01188434	11.88433986	3.57	696.40
335	0.004872271	0.150093148	1.801117778	0.011587191	11.58719104	3.48	699.88
340	0.004791669	0.147610157	1.771321885	0.011395504	11.39550412	3.42	703.30
345	0.004711067	0.145127166	1.741525992	0.011203817	11.20381721	3.36	706.66
350	0.004586117	0.141278005	1.695336064	0.010906662	10.90666201	3.27	709.93
355	0.004497246	0.138540298	1.662483572	0.010695311	10.69531098	3.21	713.14
360	0.000444422	0.013690686	0.164288229	0.001056921	1.056920939	0.32	713.46



Summary of Flows and Volumes

Measure No.	Description	Peak Flow (m ³ /s)	Volume (m ³)	Volume from model (m ³)	Depth from model (m)
Drainage 1	Clean stone drain behind Beechwood Ave, picking up stream and diverting and discharging to new channel	0.26			
Drainage 2	New pipe in Derry Road, gullies at bus layby to catch runoff. Discharge to new channel.	0.85			
Drainage 3	New pipe in Castle Road (North), new gullies at upstream extent. Discharge to D8.	0.42			
Drainage 4	New pipe through the Diamond, new gullies in Diamond and Irish Row. Discharge to D8.	0.44			
Drainage 5	New gullies and ramp at boxing club, raised kerbs at McCullagh's Corner, new pipe on Guesthouse End. Discharge to D9	0.23			
Drainage 6	New pipe in Meetinghouse Street and gullies where required. Discharge to D10	0.26			
Drainage 7	Divert pipe from Cathedral Hill to D10, collect runoff from school at entrance with gullies and discharge to D10.	0.68			
Drainage 10	Existing 450mm/600mm pipe - upgrade to take 6&7. Gullies at low point in green. Discharge to watercourse.	0.94			
Drainage 8	New pipe in Castle Road (South) + D3 + D4. Discharge to D9.	0.95			
Drainage 9	D8 + D5 discharging to watercourse.	1.18			
Secondary 5	Divert flow into field, open channel, new road culvert.		4479.08	3978.40	1.96
Secondary 12	Embankment to create storage area beside Irish Row.		850.22	680.40	1.54
Secondary 6	Embankment to create storage area above town.		2376.45	2356.00	2.53
Secondary 8	Embankment to create storage area south of Derry Road.		2237.45	1745.00	1.15
Secondary 10	Storage ditch.		442.02	393.20	0.81

Additional drainage measures:

Ramps and gullies along Derry Road

Embankments at disused quarry to convey flow past nursery and new house

Ramp and gully at Castle View

Ramps and gullies on Killygordon Road

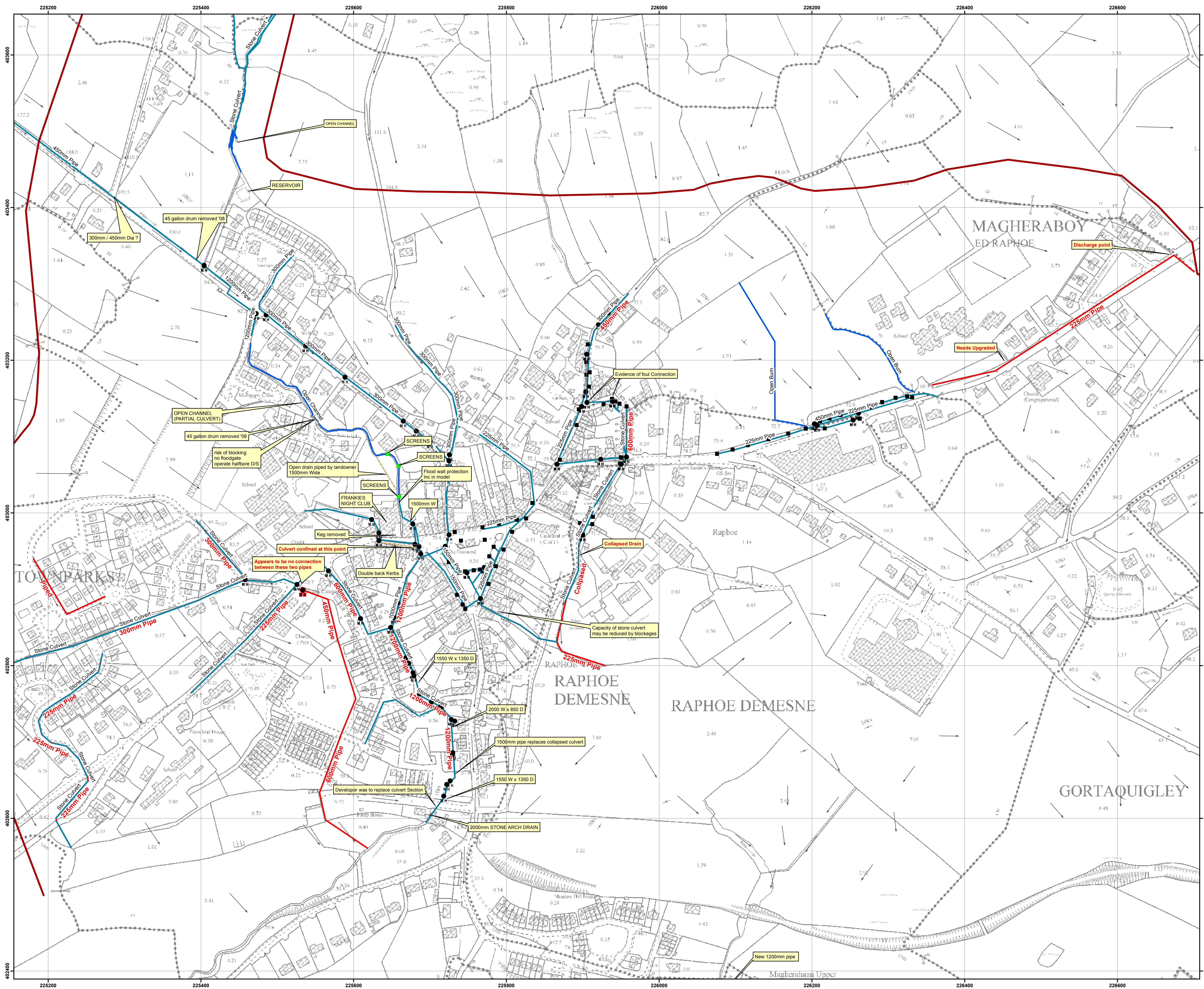
Ramps and gullies at primary school

Embankment and drain at old railway

Take runoff from road south of railway

Appendix G

Map of Existing Drainage Infrastructure



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Legend

- 403000
- Flow_Arrows
- Primary Option
- Screens
- Manholes
- Additional Manholes
- Gully
- Noted
- Drainage Systems**
- Piped
- Stone Drain
- Open Channel
- Open Burn
- Updated drainage info

RAPHOE FRAMS



The Office of Public Works Elmwood House T +44(0) 28 90 667914
Jonathan Swift Street 74 Boucher Road F +44(0) 28 90 668286
Trim Belfast W www.rpsgroup.com
Co Meath BT12 6RZ E Ireland@rpsgroup.com

Map:
EXISTING DRAINAGE SYSTEMS -
DCC MEETING UPDATES

4026 Map Type: CULVERTS & DRAINAGE

Source: Pluvial

Map Area: Raphoe
Scenario: Drainage

Drawn By : J.D Date : 27th October 2015

Checked By : A.J	Date : 27th October 2015
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Approved By :G.G Date : 27th October 2015

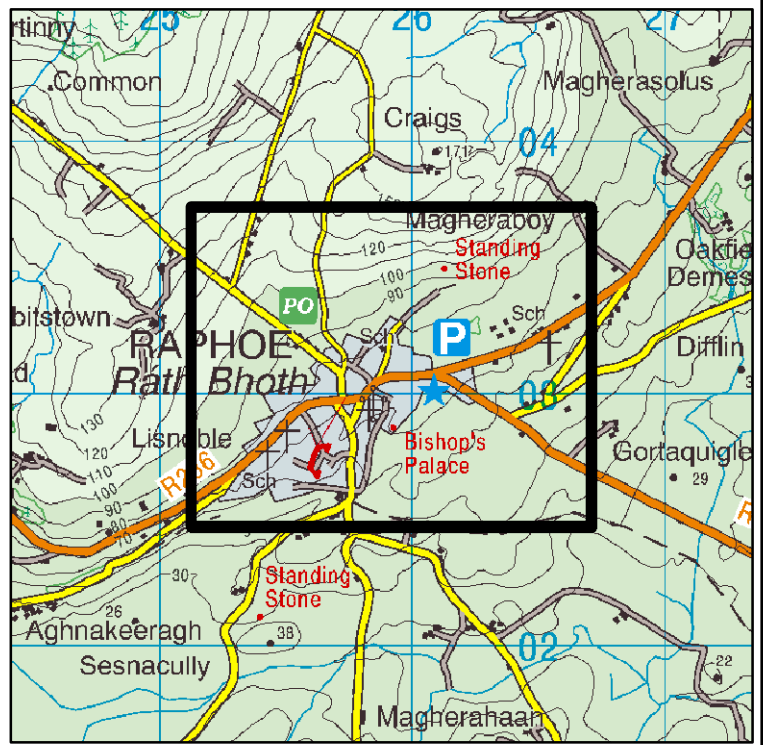
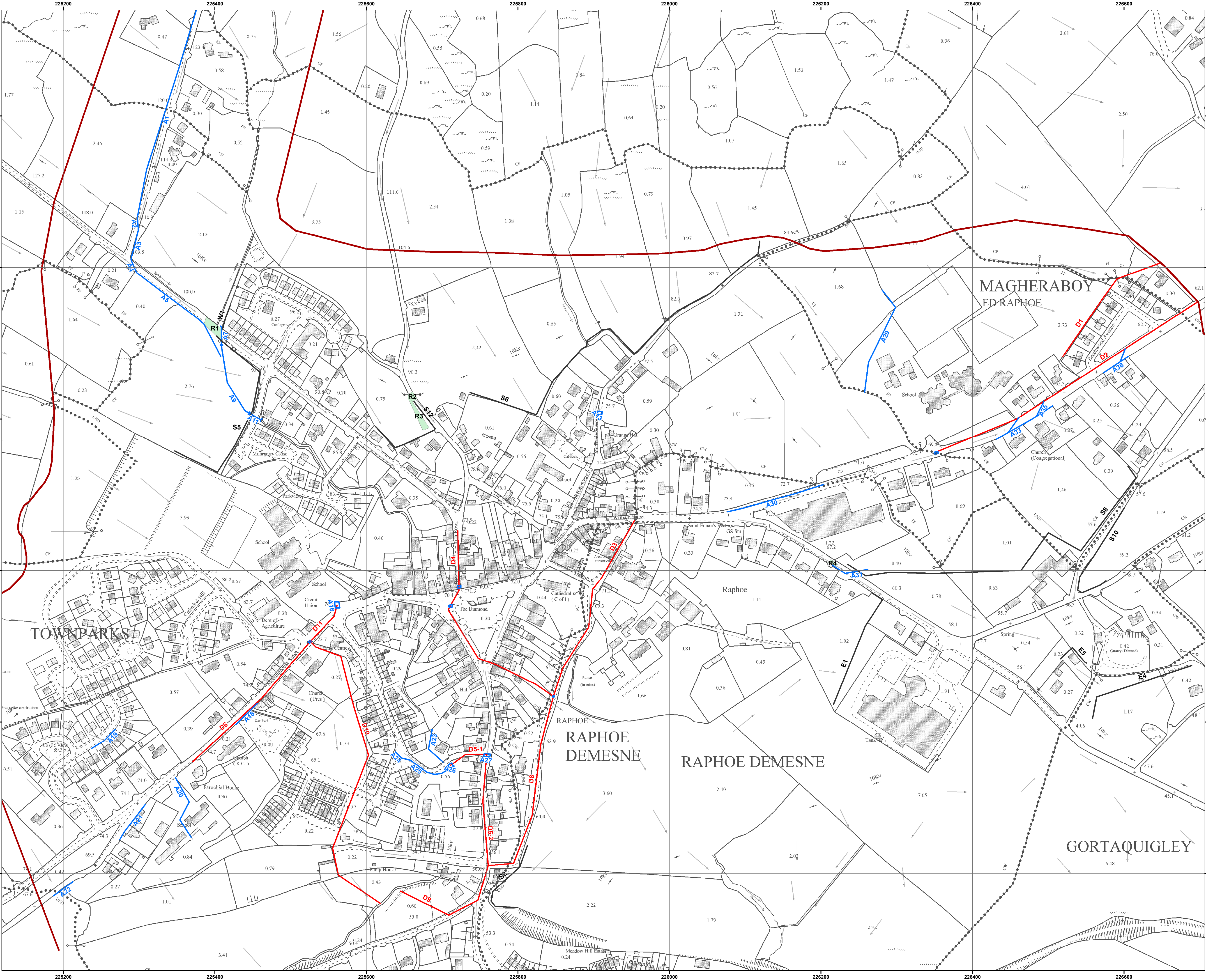
Drawing No. :
IBE0809 A1 003

Map Series :

Drawing Scale : 1:2,250 @A1

Appendix H

Proposed Final Secondary Measures to Manage Residual Flood Risk within the Urban Area



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- Legend**
- Primary Option
 - Secondary Measures - Hard Defences
 - Secondary Measures - Additional Works
 - Secondary Measures - Drainage Infrastructure
 - Secondary Measures - Polygons

RAPHOE FRAMS



The Office of Public Works
Jonathan Swift Street
Trim
Co Meath

Elmwood House T +44(0) 28 90 667914
74 Boucher Road F +44(0) 28 90 668286
Belfast W www.rpsgroup.com
BT12 6RZ E ireland@rpsgroup.com

Map: SECONDARY MEASURES WITH ID REFERENCES	
Map Type: CULVERTS & DRAINAGE	
Source: Pluvial	
Map Area: Raphoe	
Scenario: Drainage	
Drawn By : J.D	Date : 27th October 2015
Checked By : A.J	Date : 27th October 2015
Approved By : G.G	Date : 27th October 2015
Drawing No. : IBE0809_A1_005	
Map Series :	
Drawing Scale : 1:2,250 @A1	

Appendix I

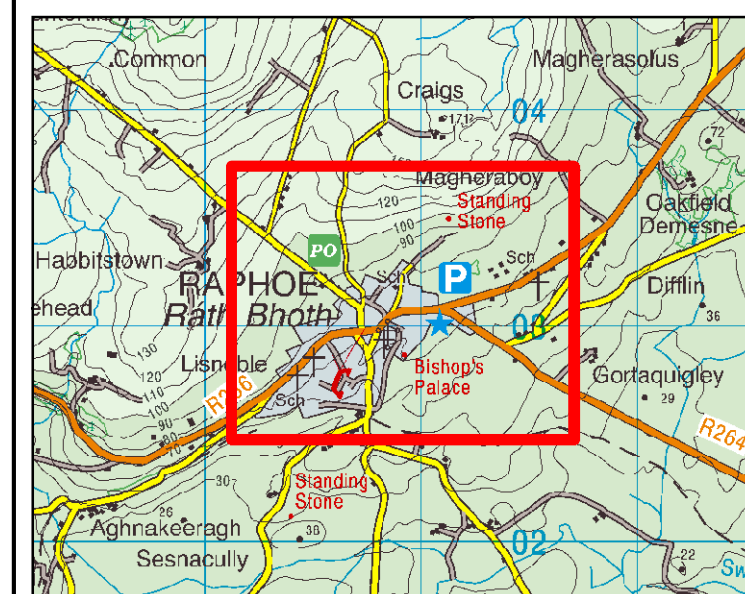
Proposed Final Secondary Measures - Breakdown of Costs

Summary - Secondary Measures Costing				
FinalRefNo	Description	Project construction cost (excl. maintenance)	Project whole life maintenance cost	Project whole life cost
W1	Head Wall to Directed Overflow Towards Storage Area	€ 29,300	€ 2,800	€ 32,100
E1	Embankment to divert flow	€ 48,500	€ 4,700	€ 53,200
E4	Embankment to divert flow around new property	€ 67,200	€ 6,500	€ 73,700
E5	Embankment to divert flow around premises	€ 15,500	€ 1,500	€ 17,000
S2	Storage Embankment	€ 47,600	€ 4,600	€ 52,200
S5	Embankment to Provide Storage	€ 256,600	€ 24,800	€ 281,400
S6	Storage Embankment	€ 322,400	€ 31,100	€ 353,500
S8	Storage Embankment	€ 332,700	€ 32,100	€ 364,800
S10	Storage Embankment	€ 82,800	€ 8,000	€ 90,800
S12	Storage Embankment	€ 90,100	€ 8,700	€ 98,800
D1	Stone drain to intercept runoff and flow from stream, discharging into channel of the primary option	€ 155,400	€ 15,000	€ 170,400
D2	Replace existing 225mm pipe with 1800mm pipe and collect gullies	€ 817,300	€ 78,900	€ 896,200
D3	Upgrade pipe along Castle Road	€ 533,500	€ 51,500	€ 585,000
D4	New pipe, replacing existing stone drain between Diamond and Castle Road	€ 318,500	€ 30,700	€ 349,200
D5-1	Pipe between collection point and new pipe along Guesthouse End	€ 64,400	€ 6,200	€ 70,600
D5-2	New pipe along Guesthouse End	€ 157,100	€ 15,200	€ 172,300
D6	New pipe with extensive gullies	€ 229,000	€ 22,100	€ 251,100
D7	Existing pipe being used, no upgrades or changes	-	-	-
D8	Upgrade pipe along Castle Road	€ 813,600	€ 78,500	€ 892,100
D9	New pipe along Carnowen Road and discharge to watercourse	€ 268,400	€ 25,900	€ 294,300
D10	Upgrade existing 450mm and possibly 600mm depending on condition	€ 421,500	€ 40,700	€ 462,200
D11	New pipe to direct flow away from St Eunans Terrace and the Diamond into upgraded manhole	€ 72,800	€ 7,000	€ 79,800
R1	Road Reprofile to Direct Runoff into Storage Area	€ 69,400	€ 6,700	€ 76,100
R2	Road Reprofile	€ 17,600	€ 1,700	€ 19,300
R3	Excavation to Convey Surface Water to Storage Area	€ 3,200	€ 300	€ 3,500
R4	Lower Existing Lane	€ 11,500	€ 1,100	€ 12,600
A1	Existing Ditch - Make Larger	€ 3,100	€ 300	€ 3,400
A2	Culvert Beneath Road	€ 5,200	€ 500	€ 5,700
A3	Create Ditch	€ 2,000	€ 200	€ 2,200
A4	Culvert to Connect Ditches	€ 5,300	€ 500	€ 5,800
A5	Existing Ditch - Make Larger and Direct Towards Storage Area	€ 2,000	€ 200	€ 2,200
A6	Culvert Inlet	€ 23,200	€ 2,200	€ 25,400
A7	Culvert under road	€ 6,700	€ 600	€ 7,300
A8	Culvert Outlet	€ 23,200	€ 2,200	€ 25,400
A9	New Open Channel	€ 2,000	€ 200	€ 2,200
A10	Culvert Inlet (Restricted)	€ 23,200	€ 2,200	€ 25,400
A11	Culvert	€ 4,900	€ 500	€ 5,400
A12	Culvert Outlet	€ 23,200	€ 2,200	€ 25,400
A13	Cattle grid/collection grid to direct surface runoff into existing pipe	€ 4,500	€ 400	€ 4,900
A14	Gully/drain to collect surface water	€ 4,500	€ 400	€ 4,900
A15	Gully/drain to collect surface water	€ 4,500	€ 400	€ 4,900
A16	Cattle grid/collection grid to direct surface runoff into new pipe	€ 4,500	€ 400	€ 4,900
A17	Upgraded manhole to connect existing and upgraded drainage infrastructure	€ 4,600	€ 400	€ 5,000
A18	Raised kerb to get flow into pipe	€ 36,800	€ 3,600	€ 40,400
A19	Raised ramp and gullies	€ 41,800	€ 4,000	€ 45,800
A20	Raised Kerb to Divert Water Around School	€ 3,400	€ 300	€ 3,700
A21	Raised ramp and gullies to protect properties from low flood depths	€ 57,000	€ 5,500	€ 62,500
A22	Raised ramp and gullies	€ 31,100	€ 3,000	€ 34,100
A23	Bund to divert flow around property (low depths experienced with primary option in place)	€ 2,000	€ 200	€ 2,200
A24	Ramp to divert flow towards Guesthouse End	€ 2,000	€ 200	€ 2,200
A25	Raised kerb to direct surface water towards collection grid	€ 3,000	€ 300	€ 3,300
A26	Collection grid into new pipe	€ 4,500	€ 400	€ 4,900
A27	Gully/drain to collect surface water	€ 20,200	€ 2,000	€ 22,200
A28	Manhole for pipe connection	€ 4,600	€ 400	€ 5,000
A29	Raised bund to direct flow into open burn	€ 5,600	€ 500	€ 6,100
A30	Additional gullies to be added	€ 139,400	€ 13,500	€ 152,900
A31	Pipe to divert flow to storage area	€ 17,800	€ 1,700	€ 19,500
A32	Manhole to collect 225mm, 450mm, open burn and new 600mm pipe from school	€ 4,600	€ 400	€ 5,000
A33	Raised ramp and gullies to protect properties from low flood depths	€ 88,000	€ 8,500	€ 96,500
A34	Pipes to collect flow from gullies	€ 8,700	€ 800	€ 9,500
A35	Pipes to collect flow from gullies	€ 7,800	€ 800	€ 8,600
A36	Raised ramp and gullies to protect properties from low flood depths	€ 36,400	€ 3,500	€ 39,900
A37	Pipes to collect flow from gullies	€ 6,700	€ 600	€ 7,300
Total		€ 5,913,900	€ 570,300	€ 6,484,200

*Unmeasured items (20%), Optimism bias (60%), Detailed design (6%), Construction Supervision (5%), Allowance for archaeological and/or environmental monitoring/exploration (21%), Cost of land acquisition/compensation (12.5%), Allowance for art (1%) Maintenance

Appendix J

Responsibility for Implementation of Measures



Drawing Scale : 1:2,250 @A1