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An Roinn Bonneagair
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Northern Ireland Flood Risk Assessment (NIFRA) 2018

DECEMBER 2018

Acknowledgements

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Revisions

Date	Revisions Made
May 2019	Correction of minor typographical errors

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Abbreviations

AAAD	Aggregated Annual Average Damages
AAD	Annual Average Damages
AEP	Annual Exceedance Probability
AFS	Areas for Further Study
AOD	Above Ordnance Datum
APSFR	Area(s) of Potential Significant Flood Risk
ASSI	Areas of Special Scientific Interest
CC	Climate Change
DAERA	Department of Agriculture, Environment and Rural Affairs
DARD	Department of Agriculture and Rural Development
DfI	Department for Infrastructure
DfC	Department for Communities
DTM	Digital Terrain Model
EU	European Union
FGDB	File Geodatabase
FRA	Flood Risk Area
FRISM	Flood Risk Metric tool
FRMP	Flood Risk Management Plan
GIS	Geographical Information System
HSCT	Health and Social Care Trust
IPPC	Integrated Pollution Prevention Control
IRBD	International River Basin District
JBA	Jeremy Ben Associates
LiDAR	Light Detecting and Ranging
NI	Northern Ireland
NIAO	Northern Ireland Audit Office
NIEA	Northern Ireland Environmental Agency
NRPs	Non-Residential Properties
OSNI	Ordnance Survey Northern Ireland
PEDU	Performance and Efficiency Delivery Unit
PFRA	Preliminary Flood Risk Assessment
PSNI	Police Service Northern Ireland

RBD	River Basin District
RPs	Residential Properties
SAC	Special Areas of Conservation
SFRA	Significant Flood Risk Area
SMR	Sites and Monuments Records
SPA	Special Protection Areas
TAPSFR	Transitional Area(s) of Potential Significant Flood Risk
UKCMF	UK Coastal Monitoring Forecasting Service

Executive Summary

The European Directive on the Assessment and Management of Flood Risks (2007/60/EC), known as the Floods Directive (FD), requires Member States to establish a framework for the assessment and management of flood risks that aims to reduce the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity. In Northern Ireland, the Department of Agriculture and Rural Development (DARD) completed a Preliminary Flood Risk Assessment (PFRA) for river basins districts in December 2011. The Floods Directive requires that the PFRA is reviewed by 22nd December 2018. This has been carried out and an updated technical assessment 'The Northern Ireland Flood Risk Assessment (NIFRA) 2018' produced.

The PFRA provided a high level strategic assessment of flood risk in Northern Ireland and was an initial assessment using available information at that time. The review and update of the PFRA is designed to ensure that flood risk continues to be assessed and managed effectively, taking account of new and updated information and changes in risk. Our understanding of flood risk is constantly developing and improving and more detailed fluvial and coastal flood hazard and flood risk maps have been developed since the initial assessment. Updated Source-Pathway-Receptor data has been used as a basis for modelling and analysis.

The 2018 methodology differs in some aspects from that adopted in 2011. For example, in determining flood risk, the effect of existing flood defences and culverts has been taken into account and pluvial flooding has been included in the identification of Areas of Potential Significant Flood Risk (APSFR).

The NIFRA 2018 forms the output of the review and has identified those areas at greatest flood risk based on available flood hazard and risk mapping information. NIFRA has identified 12 APSFR and going forward for each of the APSFR identified, the Floods Directive requires that flood hazard and flood risk maps are reviewed and if necessary, updated and made available to the public by December 2019. A Flood Risk Management Plan (FRMP) for the period 2021 – 2027, aimed at managing and mitigating the risk of flooding within APSFR, is to be produced and made available for a six month public consultation from December 2020. In addition, 9 'Transitional Areas of Potential Significant Flood Risk' (TAPSFR), identified as APSFR in the 2011 PFRA, have been determined to ensure continuity between FRMPs and facilitate implementation of any outstanding commitments arising from delivery of objectives and measures within the 2015 – 2021 FRMPs.

1 Introduction

The European Directive on the Assessment and Management of Flood Risks (2007/60/EC), known as the Floods Directive (FD), required Member States to establish a framework for the assessment and management of flood risks that aims to reduce the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity.

The Floods Directive was transposed into Northern Ireland legislation by 'The Water Environment (Floods Directive) Regulations (Northern Ireland) 2009'.

In Northern Ireland, Rivers Agency completed a Preliminary Flood Risk Assessment[1] (PFRA) for river basin districts in December 2011, complying with Articles 4 and 5 of the Floods Directive.

The Floods Directive requires that the PFRA is reviewed and, if necessary updated by 22nd December 2018. The NIFRA 2018 forms the output of that review and has identified those areas at greatest flood risk as 'Areas of Potential Significant Flood Risk' (APSFR) based on available flood hazard and risk mapping[2] information.

1.1 Aims and Objectives

Article 14 of the Floods Directive states that the PFRA *'shall be reviewed, and if necessary updated, by 22nd December 2018 and every six years thereafter'*. In order to meet this requirement, a review of the 2011 PFRA was initiated by the Department for Infrastructure. The main objectives of this review are:

- to update the existing analysis of locations within Northern Ireland identified during the first cycle of Flood Risk Management Planning to be Areas of Potential Significant Flood Risk (APSFR) or Areas for Further Study (AFS); and
- utilising current flood hazard and flood risk mapping and available or readily derivable information, to produce a revised flood risk assessment identifying those areas where the potential impact of flooding is most significant, i.e. APSFR.

1.2 Scope

The 2011 PFRA identified 20 APSFR for which detailed Flood Risk Management Plans[3] were prepared and objectives and measures are in the process of being implemented. The PFRA also identified 49 Areas for Further Study (AFS). The scope of the review was limited to these areas which have updated information and more detailed flood hazard and risk mapping. It was concluded in the 2011 PFRA report that the flood risk from impounded water bodies (reservoirs) would be most effectively managed through reservoir safety legislation similar to that which is in place elsewhere in the UK.

Since then primary legislation entitled the Reservoirs Act (Northern Ireland) 2015 has been made. This Act makes provision for a proportionate regulatory reservoir safety framework for all Controlled Reservoirs i.e. those reservoirs capable of holding 10,000m3 or more of water above the natural level of any part of the surrounding land. It is intended that, subject to Ministerial and NI Assembly approval, the secondary legislation necessary to introduce the regulatory reservoir safety framework will be made during this Flood Risk Management cycle. Therefore the flood risk from reservoirs has not been used to identify APSFR.

1.3 Approach

The PFRA was published in December 2011 and provided a high level strategic assessment of flood risk in Northern Ireland. It looked at historical flood events as well as the potential for future flooding from all significant sources and was an initial assessment using available or readily derivable information at that time. The review of the PFRA is designed to ensure that flood risk continues to be assessed and managed effectively, taking account of new and updated information and changes in risk. Our understanding of flood risk is constantly developing and improving and therefore the 2018 methodology differs in some aspects from that adopted in 2011. Some key changes include:

- Strategic maps were used for the 2011 PFRA – more detailed fluvial and coastal flood hazard and flood risk maps have been developed since that assessment for the 20 areas identified to be APSFR and the 49 areas determined as Areas for Further Study (AFS). In total 69 areas have been modelled and mapped in detail;
- The 2018 assessment takes account of the effectiveness of existing flood defences and culverts in reducing flood risk. Flood defences were considered not to be present when determining flood risk in the 2011 PFRA - the precautionary approach adopted in respect of flood defences was highlighted in the assessment at that time which advised that it was anticipated that in the next assessment, there may be a reduction in the number of APSFR identified. The implication of this approach is that fluvial and coastal damages have reduced from those derived in the 2011 PFRA; and
- Criteria have been reviewed for determining APSFR. In considering Aggregated Annual Average Damages (AAAD) value (£), pluvial flooding has now been included in the identification of APSFR. In identifying APSFR in the 2011 PFRA, pluvial flood damage values were not taken into account.

Based on the detailed flood hazard and flood risk mapping currently available, the analysis considers:

- the sources of flooding (fluvial (rivers), coastal and pluvial (surface water));
- the probability of flood occurrence for different return periods and for different sources of flooding;

- the impacts on the flood receptors for human health, the environment, cultural heritage and economic activity in terms of severity, exposure and economic damages;
- areas that should be identified as APSFR and which should be included in the FRMP for 2021 – 27; and
- areas that should no longer be identified as APSFR.

2 Flooding in Northern Ireland

2.1 Introduction

The flood risk to properties across Northern Ireland was assessed for the 2011 PFRA. However, since that time the information regarding flood risk has been updated and significantly improved. As a result new statistics regarding the number of properties at risk are available. It is now estimated that just over 25,000 or approximately 3% of the 861,000 properties in Northern Ireland are located within the 1 in 100yr (1% Annual Exceedance Probability (AEP)) fluvial floodplain or 1 in 200yr (0.5% AEP) coastal floodplain. In addition, the surface water flood map indicates that around 24,500 or 3% of the properties in Northern Ireland are sited in areas shown to be at risk of flooding from a 1 in 200yr (0.5% AEP) pluvial event with a depth greater than 300mm.

Overall, approximately 45,000 or 5% of the properties in Northern Ireland are located within either the 1% AEP fluvial floodplain or the 0.5% AEP coastal floodplain or are sited in areas at risk of flooding from a 0.5% AEP pluvial event with a flood depth greater than 300mm.

Further, when climate change for the 2080s epoch (time period towards the end of the century) is taken into consideration for these flooding events there is an increase of approximately 14,800 properties at risk or 39%. The following sections report significant flood events that have occurred in Northern Ireland since the 2011 PFRA was undertaken.

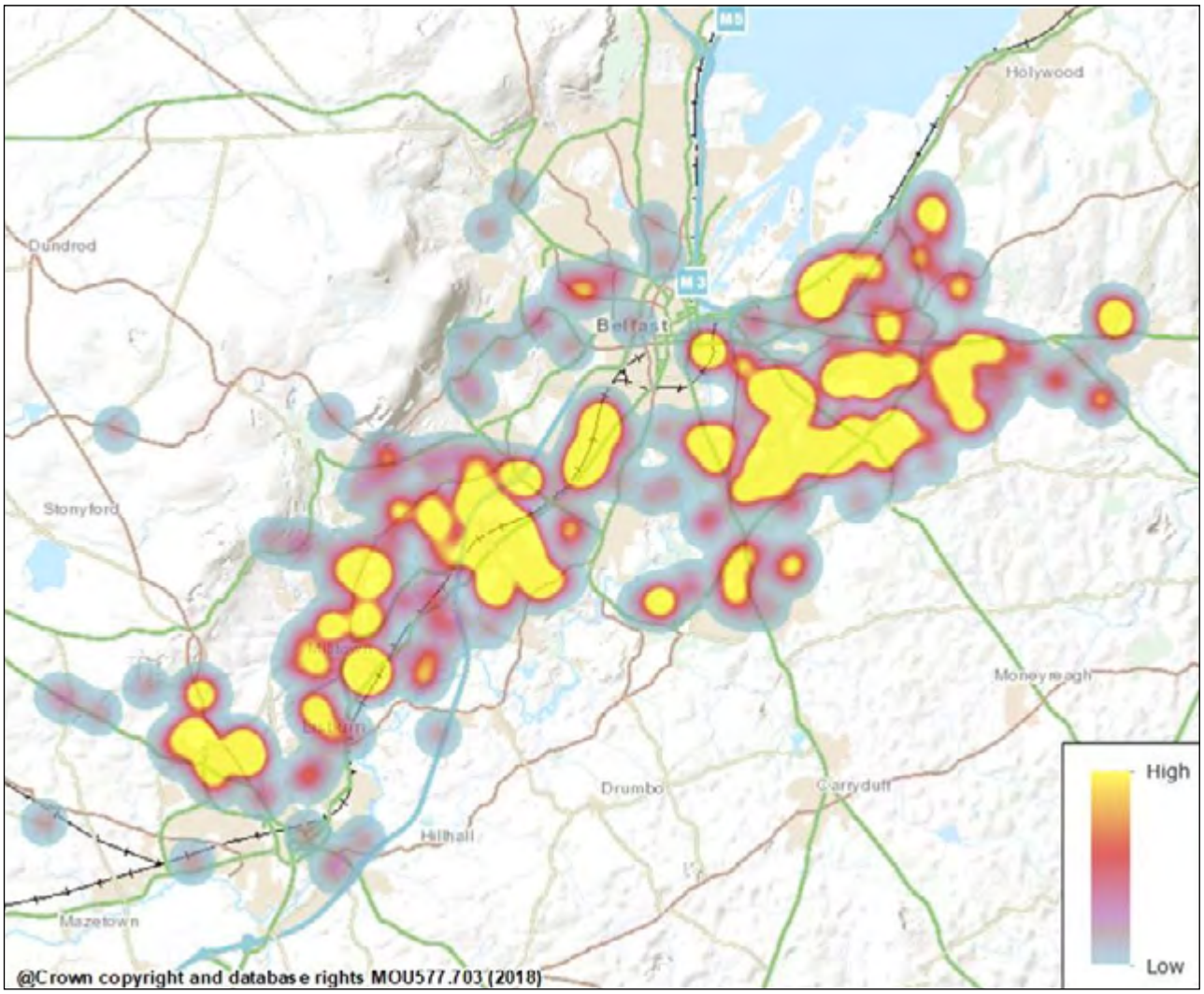
2.1.1 June 2012 - Belfast

On 27th June 2012, 44mm of rain fell in Belfast within a three hour period (Performance and Efficiency Delivery Unit (PEDU) report, 2012)[4] and this resulted in more than 1,000 flooding related incidents in South and East Belfast, with around 1,600 homes and businesses incurring damage. Over 600 emergency financial assistance payments of £1,000 were made by Belfast City Council, on behalf of the Department of the Environment, to households affected by floodwater[5] as shown in **Figure 2.1**.

2.1.2 January 2014 - NI Coastal Areas

The highest tidal surge recorded within Belfast Harbour occurred on the 4th January and 7th January 2014 (**Figure 2.2**). The initial threat to the city was assessed in the week preceding the event in consultation with the Met Office and the UK Coastal Monitoring Forecasting Service (UKCMF). A period of high astronomical tides from the 3rd to 6th January 2014 coincided with a period of strong winds and very low atmospheric pressures to give very significant tidal surges. On 3rd January 2014, a multi-agency strategic response was co-ordinated in reaction to the threat of coastal flooding. The response was co-ordinated by the PSNI given the perceived risk to life presented by the predicted extreme tidal surge.

Figure 2.1 Location of properties in Belfast and surrounding areas which were allocated emergency payments following the June 2012 flood event



High tides and strong winds caused difficult driving conditions, damage to roads and properties particularly on NI's eastern coastline and posed a significant threat to Belfast city centre[5]. However, the existing quays in Belfast were not overtopped.

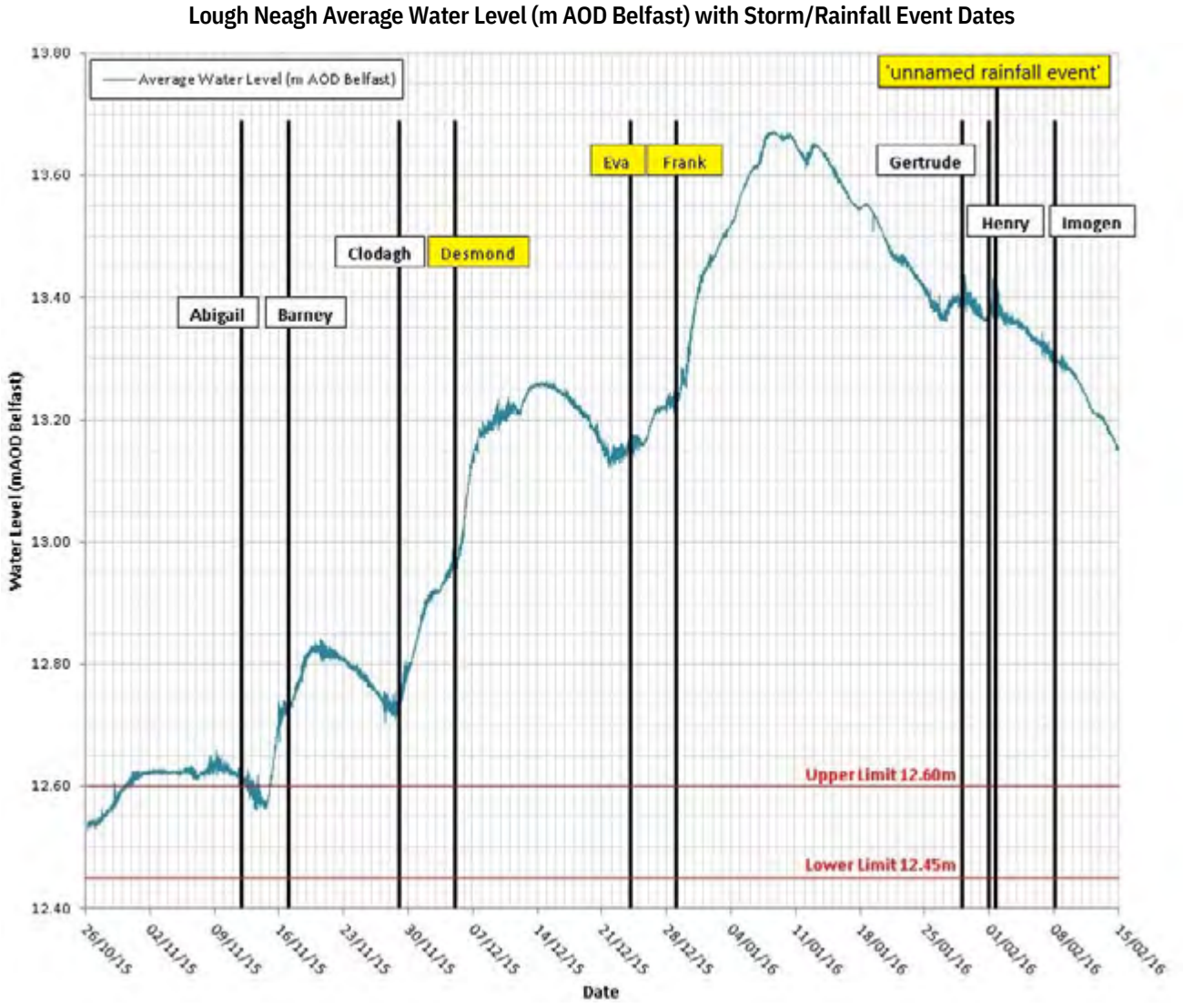
2.1.3 January and February 2016 Lough Neagh & Lough Erne Flooding

A total of four consecutive storm/rainfall events (as highlighted yellow in **Figure 2.4**) were experienced in Northern Ireland, from November 2015 through to January 2016. A report reviewing the winter floods in 2015/16 in the UK carried out by the Centre for Ecology and Hydrology[6] indicates that the rainfall recorded in Northern Ireland was representative of a >1% AEP for this period. Comparing the rainfall recorded in Northern Ireand to that of the 1971-2000 average indicated that November was 164% and December 193% above this average[7]. **Figure 2.3** shows an example of the flooding along the Upper Bann in January 2016.

Figure 2.2 Belfast Harbour January 2014 Tidal Surge

Figure 2.3 Upper Bann January 2016

Figure 2.4 Graph showing water level variation in Lough Neagh and dates of named storm/rainfall events over winter 2015/16 period



The average water level variation at Lough Neagh over the winter 2015/16 period is displayed in **Figure 2.4**, where the increases in water level can be observed as a consequence of the storms. The highest average water level from the gauges at the Lough was recorded as 13.67m AOD (Belfast); this is the highest level recorded at the Lough from 31 years of records. **Figure 2.4** also indicates the upper and lower limits (12.45m and 12.60m AOD (Belfast)), within which DfI Rivers have a statutory responsibility to control the water level as far as practicable where rainfall, wind and other natural conditions permit. The flooding affected a number of properties to the south and east of the shores of Lough Neagh, as shown in **Figure 2.5**.

The Strong Report - Review of Winter Flooding (Northern Ireland) 2015-2016[7] - was completed following this flooding which affected 174 homes, 36 commercial premises, communications routes and extensive agricultural areas. The event is regarded as significant because of the extreme hydrological conditions, the extent of land affected

Figure 2.5 Location of properties south of Lough Neagh which were allocated emergency payments following the January/February 2016 flood event

Figure 2.6 Glenrandal Bridge, Claudy

by flood water adjacent to not only Lough Neagh but also Lough Erne and the longevity of the inundation. Upper Lough Erne water levels rose to about 1m above the prescribed statutory upper limit but were 140mm below the 2009 flood event peak levels. Although flooding in the Upper Erne Catchment was lower and less extensive than in 2009, flooding occurred over a more prolonged length of time.

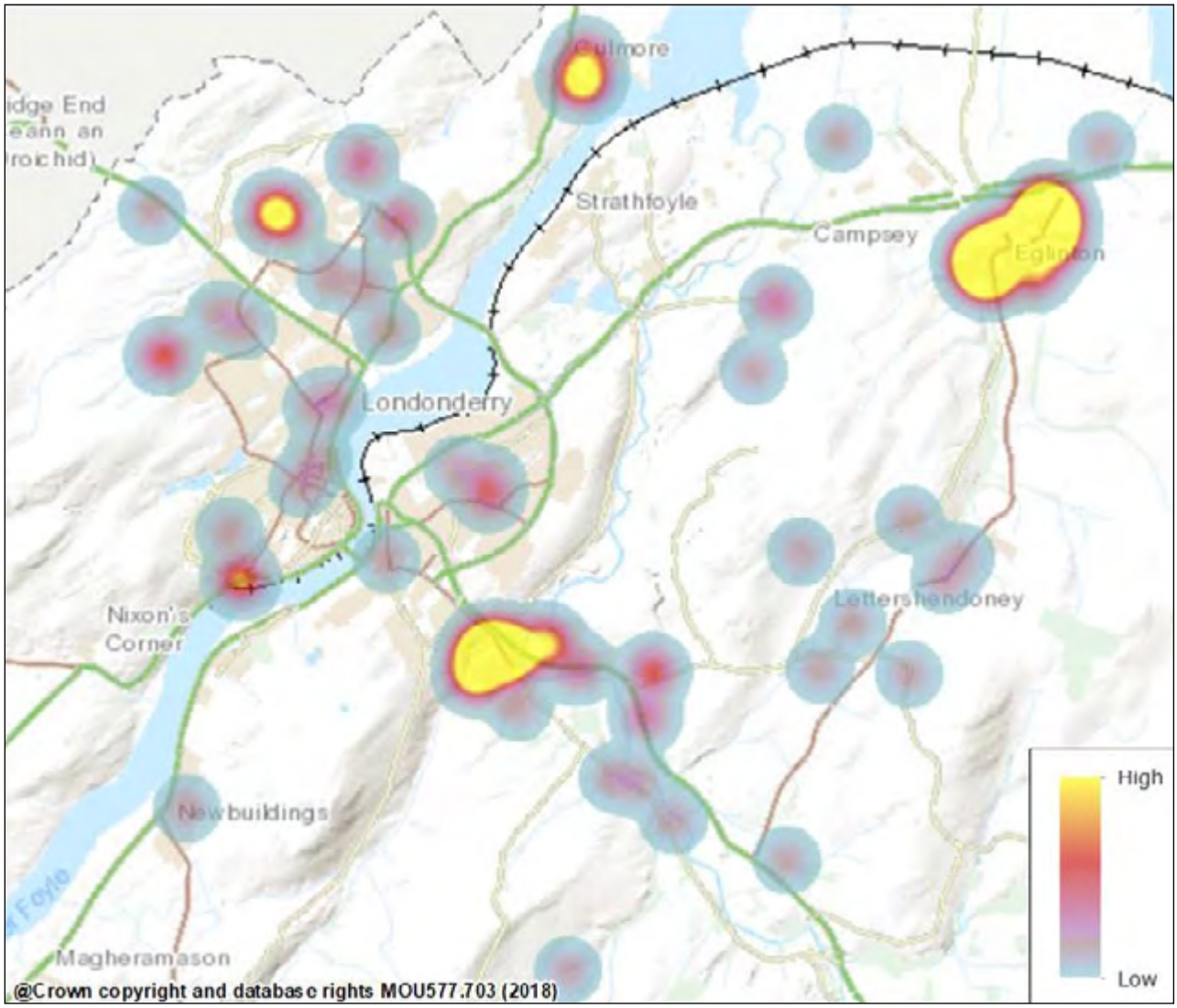
2.1.4 August 2017 - Foyle and Faughan River Catchments

During the evening of the 22nd and morning of the 23rd August 2017, the North West of Northern Ireland experienced 60-70mm of rain, equivalent to 63% of the average August rainfall, in the space of 8-9 hours. The result was that the area was subject to widespread flooding, leading to significant disruption to life at both an individual and community level. Flooding affected approximately 400 homes, numerous businesses and significant areas of agricultural land. There was also significant damage to infrastructure with 210 roads either closed or impacted and 89 bridges requiring remedial action as a result of the flooding, including the collapse of the Glenrandal Bridge in Claudy (**Figure 2.6**).

Flood defences also suffered widespread impacts with a total of 2,900m damaged at numerous locations across the North West. An indication of the areas affected by flooding during August 2017 is provided in **Figure 2.7**.

The Report "Flooding in the North West - 22nd and 23rd August 2017" [8], was completed following this flood event.

Figure 2.7 Location of properties which were allocated emergency payments following the August 2017 flood event



3 Available Datasets Relating to Flood Risk

3.1 Introduction

The Preliminary Flood Risk Assessment (2011) report examined the spatial distribution of flood risk through the use of flood risk indicators. Flood risk indicators (or metrics) are quantified estimates of the risk level of the various receptors to adverse impacts due to flooding. Such metrics can include counts of properties, key infrastructure, road length, etc. The use of these indicators generates a clearer picture of the level of risk that exists in a given location from a particular source and scenario of flooding.

Available data was divided into three categories based on a Source-Pathway-Receptor model, the main elements of which can be described as follows:

- **Sources** of flooding categorised into river (fluvial), coastal and surface water (pluvial) flooding.
- **Pathways** to receptors require information on the topography, typically using a Digital Terrain Model, but also includes knowledge of flood defence crest height data for defence overtopping. Unlike the 2011 PFRA, the modelled outlines (for fluvial and coastal flood sources) are all based upon defended flood risk and culverted watercourses have also been taken into account.
- **Receptor** data includes building polygons (ground floor footprints) of different types, key road and rail infrastructure and, key services of different classes (schools, hospitals, GP surgeries, emergency services etc.). Prior to the assessment, some pre-processing of receptor data was required so that receptors being input to the models were standardised (in terms of shape type - polygon, polyline, point); ensuring the outputs generated consistent flood risk indicators for each flood source and scenario.

3.2 Base Data – Sources

Table 3.1 summarises the base data on flood sources, that was obtained and used in the analysis detailed in Section 4 of this report.

3.3 Base Data – Pathways

The base pathway data, including topographical data (digital terrain models (DTMs) and light detecting and ranging (LiDAR) models), is used in the generation of hydraulic models to produce flood hazard mapping. The information from the hazard mapping for the various sources of flooding, is input into the receptor analysis to provide depth of flooding and flood extents which enables the identification of potential at risk receptors. The output is then used in the calculation of Annual Average Damages (AADs) associated with those receptors.

Table 3.1 Base Data - Sources

Description	Provenance	Main Use
Fluvial flood outlines for a range of AEP including 10%, 1% and 0.1% (Present Day and Climate Change)	Rivers - updated periodically as required between 2011 and 2018	Querying receptor data and annualising outputs
Coastal flood outlines for a range of AEP including 10%, 0.5% and 0.1% (Present Day and Climate Change)	Rivers - updated in 2014, 2016 and 2018	Querying receptor data and annualising outputs
Pluvial outlines of water depth > 0.1m for AEP 3.3%, 0.5% and 0.1% (Present Day and Climate Change)	Rivers /JBA - derived by JFlow using a composite DTM for all of NI comprising LiDAR & OrthoDTM early 2010	Querying receptor data and annualising outputs
Flooded Properties Heat Map	Rivers - updated July 2018	Validating technique against historical flood records

3.4 Base Data – Receptors

Four receptor groups have been included in the analysis detailed in Section 4 of this report, as shown in **Table 3.2**. Agriculture damages had little influence on the identification of APSFR in the PFRA 2011 and as the APSFR and AFS under review are predominantly in urban areas, this receptor data has not been taken into account.

Table 3.2 Base data – Receptors

Receptor Group	Description	Provenance	Main Use
Properties	Building polygons	Rivers Agency, based on OSNI large-scale data	Understanding flood risk to properties.
Key Infrastructure	NI Roads Network	WDM_Network_040518	Understanding flood risk to key transport.
	Sewage treatment works, pumping stations, Water Treatment works, water pumping stations and service reservoirs.	Northern Ireland Water	Understanding flood risk to key infrastructure.
	Electricity substations	Northern Ireland Electricity	Understanding flood risk to key Services.
	Emergency Services (fire, police stations, hospitals, GP surgeries) Ambulance depots, public services and prisons.	NI Fire and Rescue Service, Northern HSCT, South Eastern HSCT, Southern HSCT, Western HSCT, Belfast HSCT, NI Prison Service.	Understanding flood risk to key Services.
	Telecommunications Infrastructure	British Telecom	Understanding flood risk to key Services

Table 3.2 (continued)

Receptor Group	Description	Provenance	Main Use
Key Infrastructure	Railway cuttings, embankments and sections of track at risk from flooding: identified from Translink point records.	Translink	Understanding flood risk to key transport
	Airports including Belfast International Airport, George Best Belfast City Airport and City of Derry Airport.	Belfast International Airport, George Best Belfast City Airport and Derry City & Strabane District Council respectively.	Understanding flood risk to key infrastructure.
	Power Generation - Coolkeeragh, Kilroot and Ballylumford	Coolkeeragh ESB Ltd and AES UK & Ireland respectively.	Understanding flood risk to key infrastructure.
	Sea Ports	Warrenpoint Port, Port of Larne, Foyle Port and Belfast Harbour.	Understanding flood risk to key infrastructure.
Environment	ASSIs, SPAs and SAC Sites	Department for Agriculture, Environment and Rural Affairs (DAERA) online data access website.	Understanding flood risk to the environment.
	Integrated Pollution Prevention and Control sites (IPPC)	Northern Ireland Environment Agency	Understanding flood risk to the environment from waterborne pollutants.
Cultural Heritage	Listed buildings, Historic Parks and Gardens, Sites and Monuments Records (SMR) and Sites of Archaeological Interest.	Department for Communities (DfC) online data access portal	Understanding flood risk to cultural heritage.

4 Methodology

4.1 Introduction

As outlined previously, our understanding of flood risk is constantly developing and improving and therefore the 2018 methodology differs in some aspects from that adopted in 2011. The methodology details the procedures used to highlight areas predicted to be at risk of flooding from one or more sources. Such areas are referred to as Flood Risk Areas (FRAs). The methodology adopted for undertaking the review of the PFRA and detecting FRAs can be summarised in two main stages:

1. **Receptor Analysis** – this includes any pre-processing of receptor data and the assessment of receptors in relation to their position within a flooded area extent; and
2. **Risk Analysis (Grid Based)** – this involved combining the receptors and flood sources to produce a 1km grid covering Northern Ireland. Core high risk cells were determined initially using "at risk" property flood data. Further analysis led to clusters of flood risk being highlighted which were assessed in relation to other receptors at risk. This process identified high risk clusters in which flooding could be considered to have a significant impact, i.e. to be significant flood risk areas.

Available flood hazard mapping (see **Table 3.1**), with the inclusion of flood defences and culverts to better represent flood extents and mechanisms (flood defences and culverts were not included in the PFRA (2011)) was utilised. The flood mapping included high, medium and low probability events for all flood sources (**Table 4.1**).

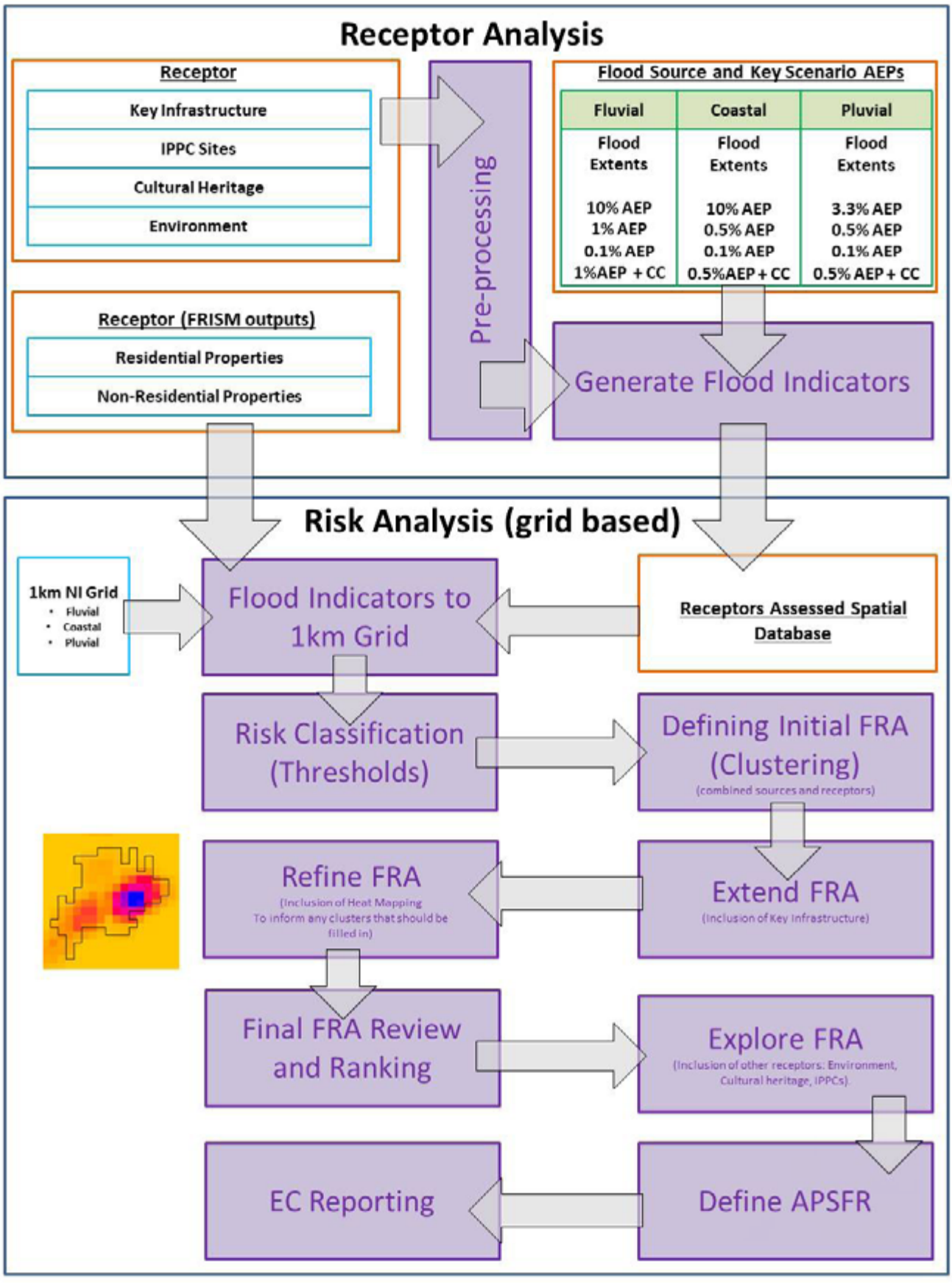
Table 4.1 Flood Source and Key Scenario AEPs

	Flood Source		
Event Probability	Fluvial	Coastal	Pluvial
High	10%	10%	3.30%
Medium	1%	0.5%	0.5%
Low	0.1%	0.1%	0.1%
Climate Change	1% + CC	0.5% + CC	0.5% + CC

In determining FRAs and from these, the derivation of APSFR (section 5.3 refers), predicted damages incurred from pluvial flooding have been included in the analysis and thus scoring of flood risk grid cells. This was not taken into account in the identification of APSFR in 2011.

The adopted methodology workflow is presented in **Figure 4.1**, with details of each stage provided in the remaining sections in Chapter 4 of this report.

Figure 4.1 Methodology for the development of the 2018 Flood Risk Assessment



4.2 Climate Change

Scientific evidence shows that the world's climate is changing. In Northern Ireland, it is expected that the amounts and intensities of rainfall will increase. There will be a trend towards stormier, more extreme weather conditions and coastal areas will be affected by rising sea levels. These changing conditions will increase the risk of flooding. Communities already at risk could see an increase in the severity or frequency of flooding and other communities not currently at risk may become affected. For Northern Ireland, medium probability scenarios have been considered in assessing the impacts of Climate Change on flood risk for the 2080s epoch (time period). The NIFRA 2018 includes an analysis of the impacts of fluvial, coastal and pluvial sources on receptors. This serves to highlight areas that are particularly susceptible to increased flood risk due to climatic changes and allows such areas to be considered in setting future objectives and measures to manage flood risk. The analysis has considered increases in economic damages, annualised counts of key infrastructure and people at risk, however, due to the absence of readily derivable information, predicted changes in flood risk due to climate change have not taken into account future population change, development pressures or urban expansion/growth/creep.

4.3 Source and Receptor Data Analysis

4.3.1 Source Data

Using the data outlined in Section 3, the receptors that are potentially at risk of flooding were identified. While Residential and Non-Residential Properties (RPs and NRPs respectively) were assessed using Flood RISk Metric tool (FRISM developed by JBA Consulting), other receptors were classified as being "at risk" if they intersected a flood extent for the low, medium or high probability flood events. However, for the climate change scenario, the available hazard mapping was used to determine the increase count in properties at risk of flooding for each of the sources and to highlight areas that are particularly prone to an elevated level of flood risk due to the effects of climate change.

4.3.2 Receptor Data

The receptor analysis utilised a Geographical Information Systems (GIS) based approach to cross-correlate receptors against flooded area extents (flood hazard) for all flood sources and scenarios. Bespoke computer models were developed which enabled consistent assessments of all receptors, flood sources and scenarios.

Receptors supplied as point data (key infrastructure, cultural heritage and IPPC sites) were buffered to ensure that the receptor was adequately represented. Analysing only a point in space against flood extents has the potential of under-estimating flood risk. Where this buffering process was implemented, the buffer distance was maintained in the dataset attribute table. Roads infrastructure was represented as polylines in GIS. These polylines were converted to polygons by buffering to 1.5m on each side of the line to achieve better representation of the roads infrastructure and to ensure a conservative analysis of flood risk.

4.3.2.1 Residential and Non-Residential Properties

RPs and NRPs were assessed by DfI Rivers and the outputs provided for all sources of flooding. This was completed using FRISM which generates costs for Annual Average Damages (AADs) per property along with annualised counts of persons at risk (based on 2.5 persons per residential property). The software operates within ArcMap (a geographic information system for working with maps and geographic information), allowing users to combine flood modelling results (e.g. depth grids) with property datasets and depth-damage parameters to assess human health (in monetary terms) and economic activity impacts such as the potential number of properties flooded, their annual average damages (AAD), or the length of the road network inundated. Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average economic damages per year that would occur at a defined location from flooding when considered over a very long period of time.

FRISM was used in conjunction with the Flood Hazard Research Centre's Multi-Coloured Manual. This manual provides typical property damages, emergency costs, indirect and intangible damages and agricultural damages (where appropriate), to assist in the computation of the economic damages.

4.3.2.2 Key Infrastructure (Services and Transport)

All key infrastructure data sets listed in Section 3.4 were included in the assessment. Counts of key infrastructure within each grid cell were captured for each source and scenario. These statistics were then transposed to the 1km Northern Ireland grid and finally combined into a composite key infrastructure risk grid.

4.3.2.3 Natural Environment and IPPC Sites

Although environmental metrics may help identify specific areas where flooding could potentially cause some adverse effects to the environment, they are not a reliable indicator of the actual level of risk. In some cases the flooding of an Area of Special Scientific Interest (ASSIs) may have a damaging, neutral or even a beneficial effect. There is very little literature available on the environmental vulnerability of designated environmental sites to the effects of flooding. The main conclusion to be drawn from a literature search is that an assessment of the vulnerability of protected natural sites is complex and needs to be undertaken on a site by site basis. Thus, environmental metrics were used within each FRA to assess the likely impact of flooding to the environment in terms of the annualised average number of sites affected. The inclusion of the protected sites in the analysis serves to provide additional information to that of the other flood receptors in the FRAs.

Northern Ireland's ASSIs represent the country's very best wildlife and geological sites. Special Areas of Conservation (SAC), Special Protection Areas (SPA), and Ramsar sites are designated due to their international importance, most of which align with the ASSI network. Other national designations include Nature Reserves and National Nature Reserves. For the purposes of the analysis, protected sites that intersected

a flood extent were identified as potentially at risk of flooding and were assigned a binary indicator for each source of flooding and scenario. Potentially significant risks to the designated sites may arise from the release of pollutants from flooded Integrated Pollution Prevention and Control (IPPC) sites and they were treated in a similar way to protected sites for analysis purposes.

There was consultation with Northern Ireland Environment Agency (NIEA), which has a responsibility to conserve and protect our natural environment, regarding the approach adopted for assessing the environmental aspects.

4.3.2.4 Cultural Heritage

Cultural heritage metrics were used within each FRA to assess the likely impact of flooding to cultural heritage in terms of the annualised average number of sites affected. The inclusion of cultural heritage sites in the analysis serves to provide additional information to that of the other flood receptors in the FRAs.

The Department for Communities (DfC) provided four key datasets that were then used in the assessment of flood risk to cultural heritage. These included Listed Buildings, Historic Parks and Gardens, Sites and Monuments Records and Sites of Archaeological Interest.

Cultural heritage sites that intersected a flood extent were identified as potentially at risk of flooding and were assigned a binary risk indicator for each source of flooding and scenario for the purposes of analysis.

There was consultation with the DfC regarding the approach adopted for the cultural heritage assessment.

4.4 Risk Analysis

After assessing the receptors against all flood sources and scenarios (as detailed in **Table 4.1**) the results were summarised and the flood risk interpreted across Northern Ireland. A common approach is to spatially summarise the flood data using simple statistics such as affected receptor counts, damages, areas etc. within a constant radius or grid. A grid approach is commonly used throughout the UK by responsible flood authorities and throughout Europe by the wider European flood authority community. This approach was adopted as it offers an opportunity to derive representative clusters that capture cells within and around the APSFR and AFS derived under the 2011 PFRA report methodology.

Only strategic pluvial mapping based on broad-scale modelling methodology was available for this Review and that mapping had clear limitations, especially when compared to the detailed mapping available for fluvial and coastal sources of flooding. Given this background and taking into account different design standards employed for the various sources of flooding, the approach adopted should ensure that outputs are reasonable.

4.4.1 Grid-Based Analysis

Flood risk data derived from the receptor analysis for Northern Ireland was summarised to a 1km grid. A separate grid was created for each receptor and each source where the summarised flood data for each scenario was stored. For example, the property risk grids include the summation of AAAD for fluvial, coastal and pluvial sources and also annualised average counts of "at risk" property within each grid cell. Other receptors such as cultural heritage, environment and key infrastructure include the number of receptors "at risk" for each source and scenario, as well as the annualised average count of these "at risk" receptors.

A combined source key infrastructure grid was generated using only the high probability events. It was assumed that road drainage infrastructure provides normal standards of protection against these high probability events. This assumption, combined with the strategic nature of the pluvial flood mapping, led to the decision to exclude roads affected in the high probability (regular) pluvial flood events. So while damages to RPs and NRPs were used to derive the initial FRAs, key infrastructure was used to extend the coverage of FRAs, where appropriate.

4.4.2 Defining Cells for Initial FRAs

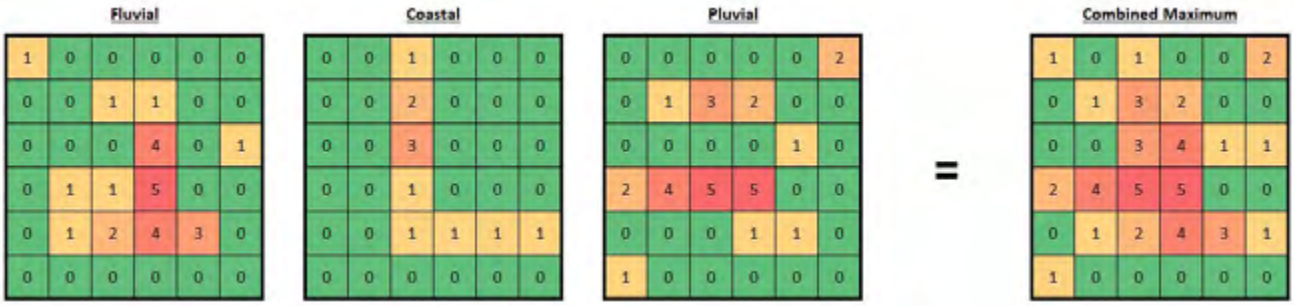
An analysis of the RPs and NRPs FRISM outputs was undertaken on a 1km grid basis. This analysis formed the basis for determining the cells for initial FRAs. It entailed setting thresholds based on the value of average annual damages (AADs) for each flood source within each grid cell and then numeric risk classes were assigned. The thresholds and associated risk classes defined in **Table 4.2** were assigned to the risk grids for each source.

Table 4.2 Grid Risk Classification Thresholds

Criteria	Risk Class	Risk Label
AADs > £250,000	5	Very High
£100,000 < AADs <= £250,000	4	High
£50,000 < AADs <= £100,000	3	Medium
£20,000 < AADs <= £50,000	2	Low
£1 < AADs <= £20,000	1	Very Low

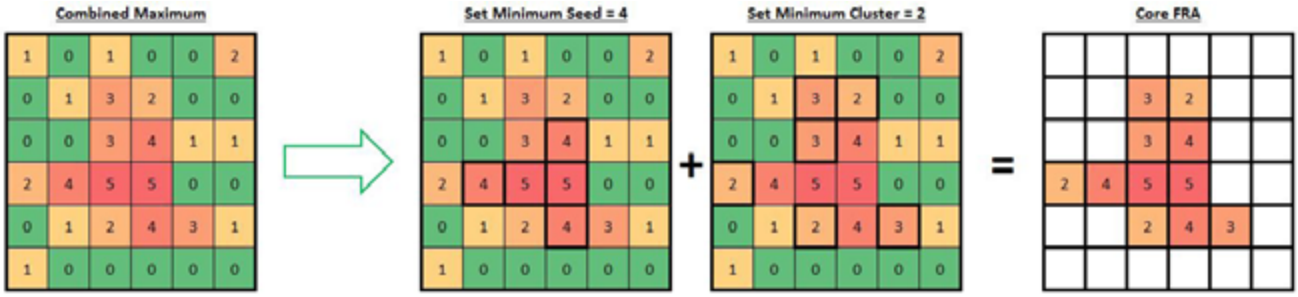
The grids for all sources were then combined to produce a composite risk grid where the maximum risk score between all sources is carried forward in the analysis. This process is illustrated in **Figure 4.2**.

Figure 4.2 Producing Composite Risk Grid



The output, a Combined Maximum composite risk grid, was input to a clustering analysis. The clustering algorithm was undertaken by selecting cells that corresponded to an initial seed value. The seed was then 'grown' based on a defined minimum cluster threshold. Clusters were formed only when the cells were contiguous (with square connectivity). Once the seed ceased to grow, this marked the end of the initial analysis and the output formed the cells for the initial FRAs. For this analysis, the minimum cluster seed was set at the high risk class (4) and clustering considered only those cells whose risk level was low (2) or above. Additionally, the analysis was undertaken separately for each river basin district (RBD) such that clusters in one RBD did not merge into an adjacent RBD. An example of the clustering process is illustrated in **Figure 4.3**.

Figure 4.3 Defining Initial FRAs



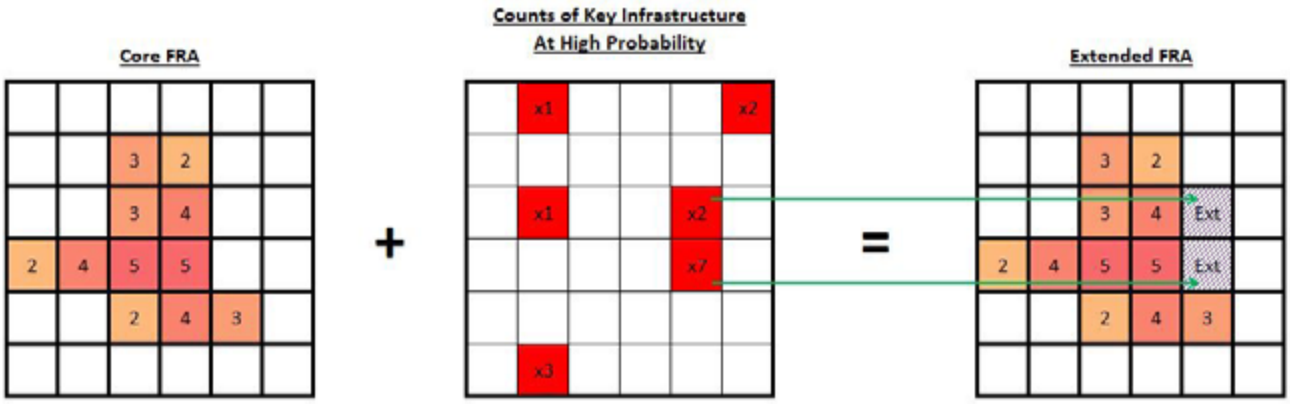
4.4.3 Extending Initial FRAs

The clustering analysis described above produced cells for a number of initial FRAs. The next stage was to include key infrastructure information to analyse where clusters may warrant an extension due to adverse impacts on the key infrastructure during high probability flooding events (Pluvial: 3.3% AEP, Fluvial: 10% AEP, Coastal: 10% AEP).

The combined source key infrastructure grid was then used to determine if the cells within initial FRAs should be extended. The 'blue squares' method - commonly adopted in England and Wales when undertaking similar assessments - considers 1km^2 grid squares, which contain two or more key infrastructure elements at risk of flooding in the high probability event, a significant flood risk cell[9]. When adopted this approach resulted in a number of extension cells being generated that were contiguous to a number of the cells within initial FRAs.

In the example provided in **Figure 4.4** a total of six cells are observed to contain one or more key infrastructure elements at risk in the high probability event. Only two of these cells have more than one element at risk and are contiguous to the initially identified core FRA. The other four key infrastructure cells are either not touching the core FRA or their 'at risk' key infrastructure count is less than two. Subsequently, only two cells met the extension criteria. The two cells extend the core FRA to account for the adverse impacts of flooding relating to key infrastructure.

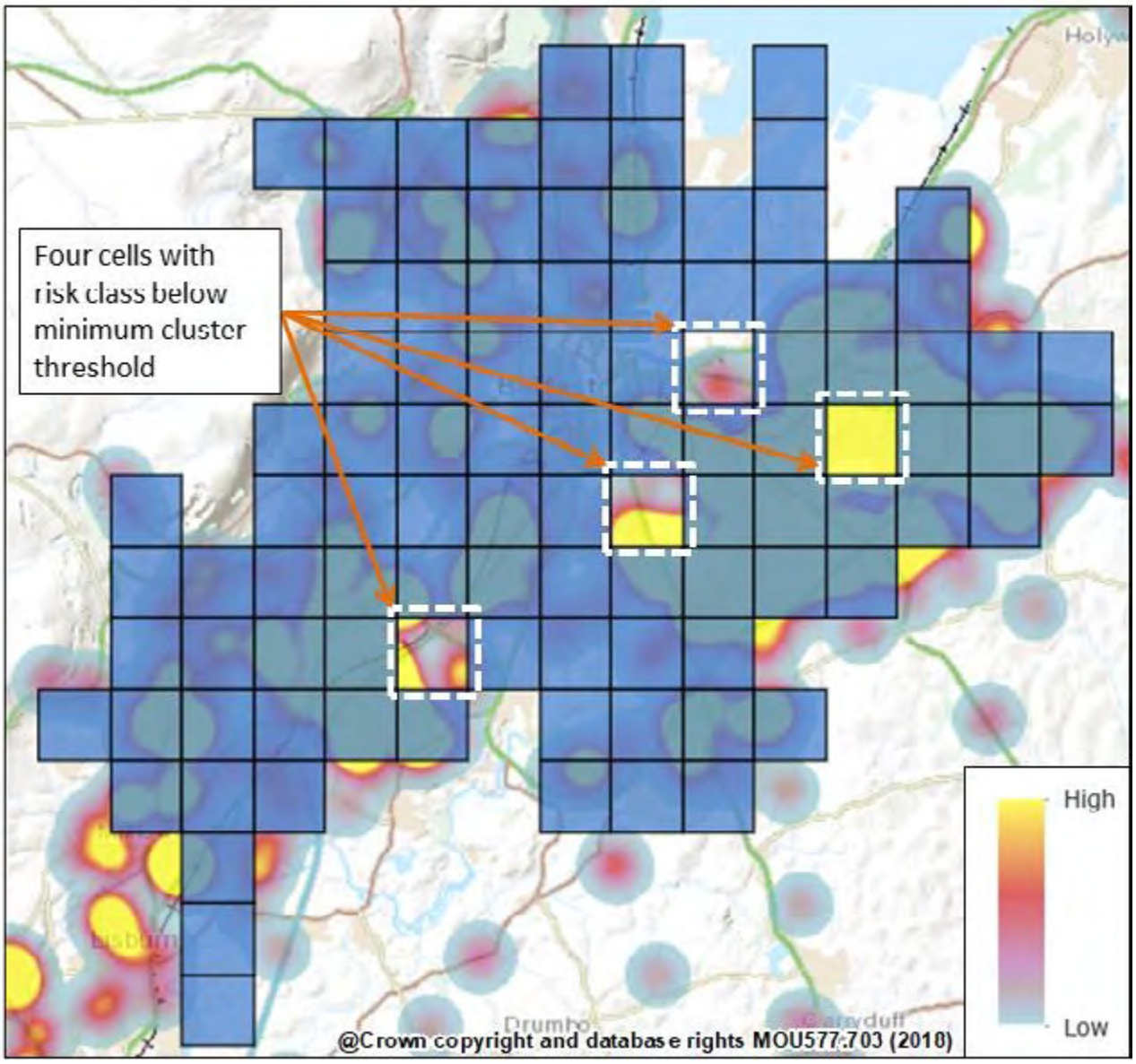
Figure 4.4 Defining Extensions to initial cells within FRAs



4.4.4 Refining Initial FRAs

A number of FRAs representing concentrations of flood risk were highlighted using the process described in the preceding sections and further validated against historic flood records. 82% of the highlighted FRAs were found to have evidence of historic flooding. There were instances where initial FRAs had blank cells within their boundary due to the fact that those cells did not meet the minimum clustering criteria. Historic flood records were reviewed to inform whether or not those cells should be filled through post-processing. In particular, Belfast had several such areas that could be included as part of the Belfast FRA. The records of the Scheme of Emergency Financial Assistance to Councils (SEFA) (which indicate instances of flooding in Northern Ireland where the householders applied for and received hardship payments from councils) were used to inform and justify the inclusion of cells within a FRA. **Figure 4.5** illustrates the procedure undertaken for the Belfast FRA whereby several internal cells were not captured through the clustering analysis as their assigned risk class is below the minimum cluster threshold (Risk Class 2). The historical flood record heat map (generated from SEFA) provides evidence to include these cells in the overall Belfast FRA. Using engineering judgement the extent of the clusters were then adjusted to take account of any anomalies.

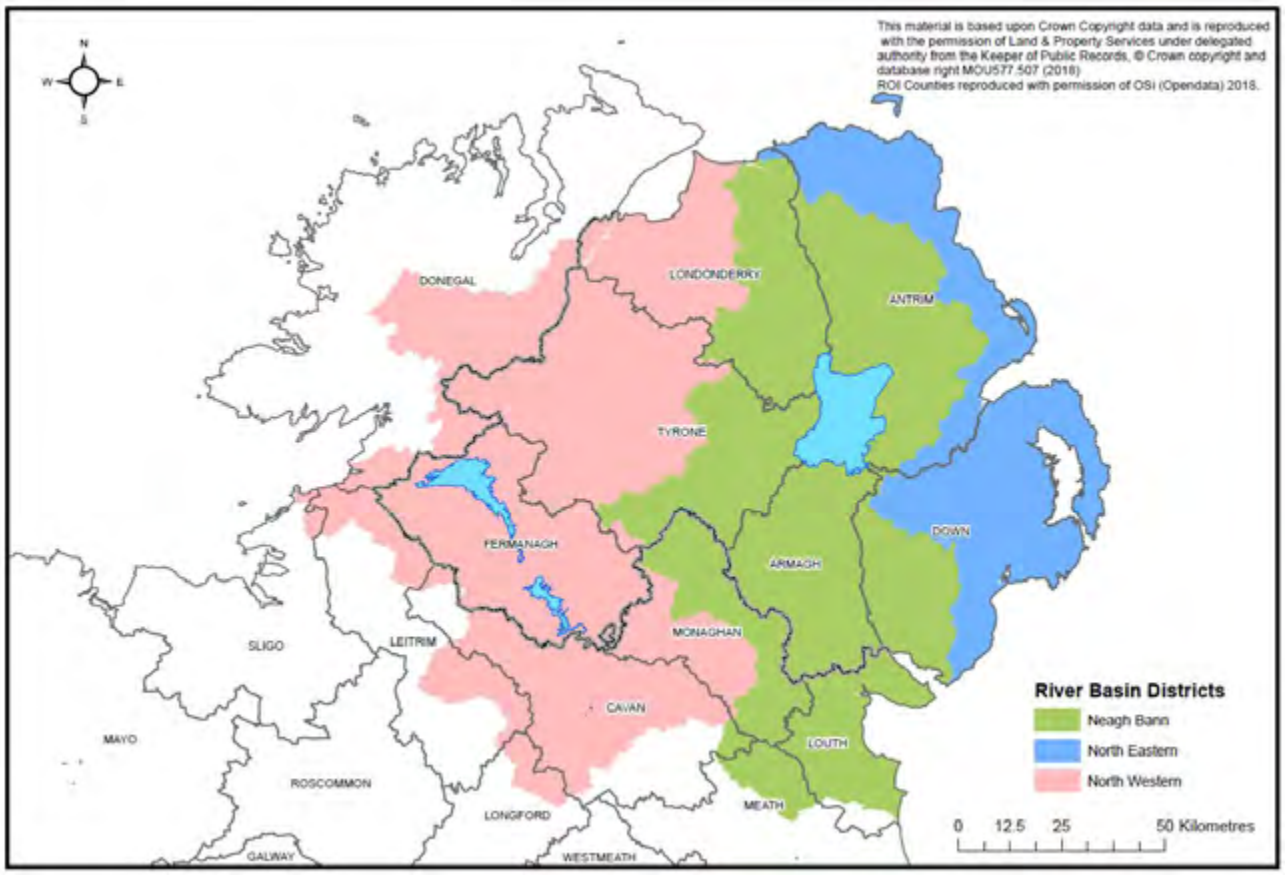
Figure 4.5 Historic Flood Records Heat Map



5 Analysis Results

The analysis highlighted a total of 45 FRAs as opposed to 69 in the 2011 PFRA. This section presents the receptor statistics captured with various pivotal summaries of flood risk across Northern Ireland's RBDs (**Figure 5.1**).

Figure 5.1 River Basin Districts



5.1 Flood Risk Area Summaries

Table 5.1 and **Table 5.2** provide a summary of the annualised average flood risk metrics which have been captured for each source of flooding across the 45 FRAs highlighted in Northern Ireland.

Table 5.1 Statistical Receptor Summary of the 45 NI FRAs

	Fluvial	Coastal	Pluvial	Totals
Total Property Damages (Millions)	£ 10.69	£ 3.45	£ 41.83	£ 55.97
Residential Property Damages (Millions)	£ 4.32	£ 0.79	£ 17.31	£ 22.42
Intangibles (Millions)*	£ 0.27	£ 0.01	£ 0.40	£ 0.68
Non-Residential Property Damages (Millions)	£ 6.10	£ 2.65	£ 24.12	£ 32.87
People at Risk	3359	173	5035	8567
Count Residential	1344	69	2013	3426
Count Non-Residential	321	81	546	948
Count Key Infrastructure	37	7	85	129
Count IPPC	2	1	4	7
Count Cultural Heritage	30	8	83	121
Count Environment	1	0	1	2

* intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Using the flood statistics obtained for the 45 FRAs, an illustration of the predicted flood risk is presented in **Figure 5.2**. Additional statistical breakdowns for FRAs in each RBD are provided in **Appendix B**.

The AAAD captured in the analysis totals £56 million. Pluvial flooding accounts for approximately 74% of this total annualised damage metric. These results indicate that pluvial flooding dominates all receptor statistics throughout the analysis. A contributory factor for this may be the strategic nature of the pluvial modelling and mapping. The names of the FRAs and total corresponding AAADs (ranked in descending order) are presented in **Table 5.2**.

Table 5.2 Flood Risk Areas

Rank	Area Name	AAAD (£ Millions)
1	Belfast	16.18
2	Londonderry	5.56
3	Newry	4.07
4	Lurgan	2.31
5	Glengormley and Mallusk	2.09
6	Larne	2.03
7	Bangor	1.84
8	Portadown and Craigavon	1.81
9	Omagh	1.70
10	Newtownabbey	1.44
11	Carrickfergus	1.17
12	Ballymena	1.07
13	Whitehouse	0.93
14	Strabane	0.91
15	Dundonald	0.88
16	Lisburn	0.79
17	Newtownards	0.77
18	Holywood	0.75
19	Armagh	0.71
20	Newcastle	0.66
21	Banbridge	0.63
22	Antrim	0.62

Rank	Area Name	AAAD (£ Millions)
23	Ballyclare	0.58
24	Coolkeeragh	0.54
25	Downpatrick	0.53
26	Coalisland	0.49
27	Limavady	0.46
28	Coleraine	0.46
29	Warrenpoint	0.40
30	Cookstown	0.40
31	Eglinton	0.35
32	Maghera	0.32
33	Ahoghill	0.30
34	Enniskillen	0.29
35	Castlederg	0.28
36	Rostrevor	0.26
37	Lisbellaw	0.25
38	Glenavy	0.23
39	Keady	0.21
40	Ballycastle	0.21
41	Stoneyford	0.18
42	Dromore	0.18
43	New Buildings	0.15
44	Artigarvan	0.15
45	Magherafelt	0.12

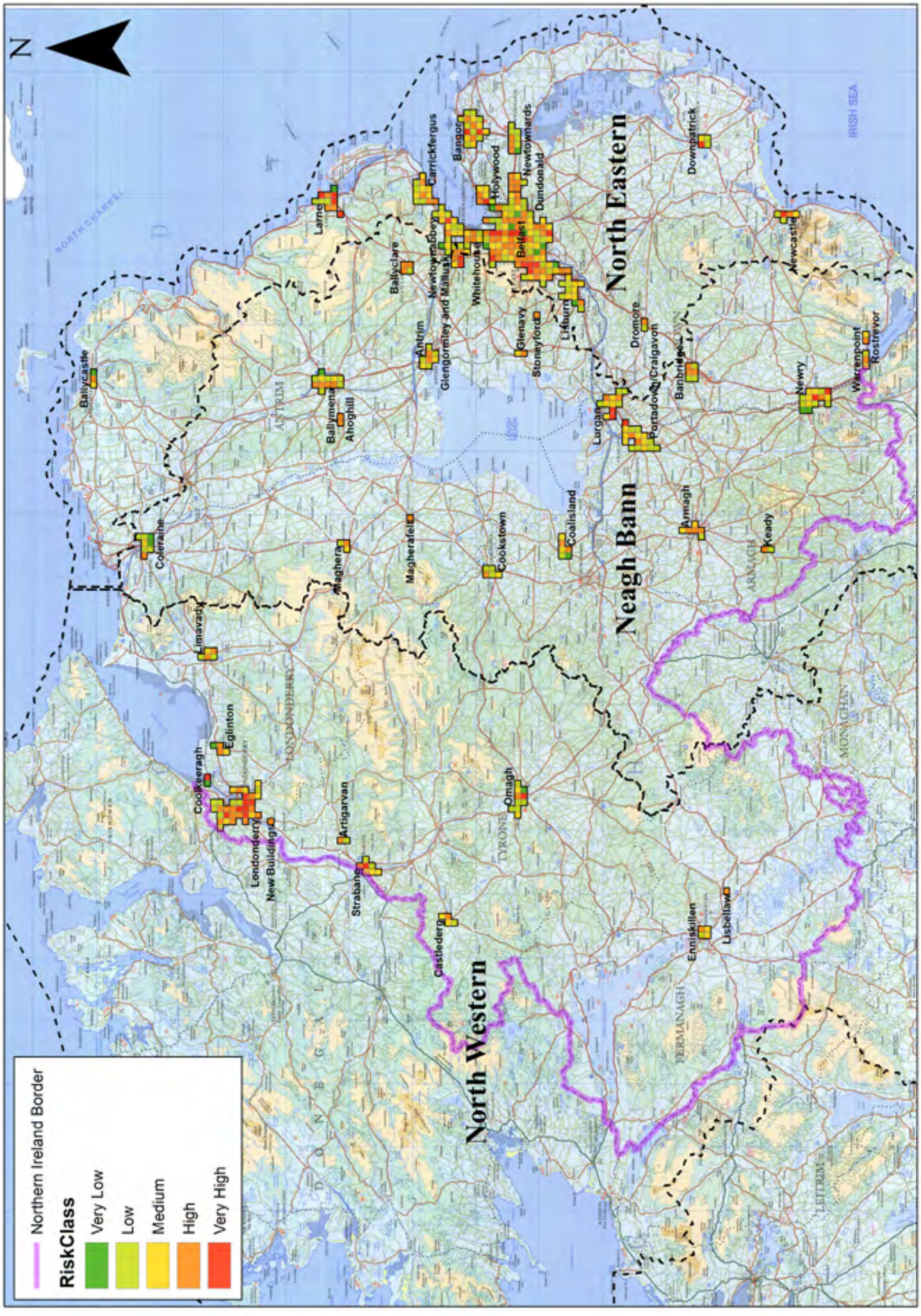


Figure 5.2 Northern Ireland Flood Risk Areas

5.2 Climate Change Analysis

A climate change analysis of "at risk" receptors has been undertaken for each FRA using the medium probability scenario for each source of flooding. The analysis aims to provide a straightforward and informative projection of the effects of climate change in relation to flood risk. The analysis revealed that there is an increase of over 8,500 residential and 2,200 non-residential properties at risk from combined sources of flooding (many of these properties may be prone to flooding from more than one source).

Figure 5.3 and **Figure 5.4** present the climate change impacts on properties by RBD and provide a breakdown of all key climate change flood risk metrics taken from the difference in receptors "at risk" counts for the medium probability event with and without climate change effects. It was observed that the North Eastern RBD is predicted to be impacted more than the other RBDs by climate change, followed by Neagh Bann RBD. The Neagh Bann coastal climate change impacts are the least significant, likely due to having the shortest length of coastline. The majority of impacts appear to be on residential properties; this is probably due to the fact that residential properties account for over 90% of the complete NI property listing. A summary of the climate change analysis is available in **Appendix B**.

Figure 5.3 Residential Property at risk - Increase in the Medium Probability event by source and by River Basin District

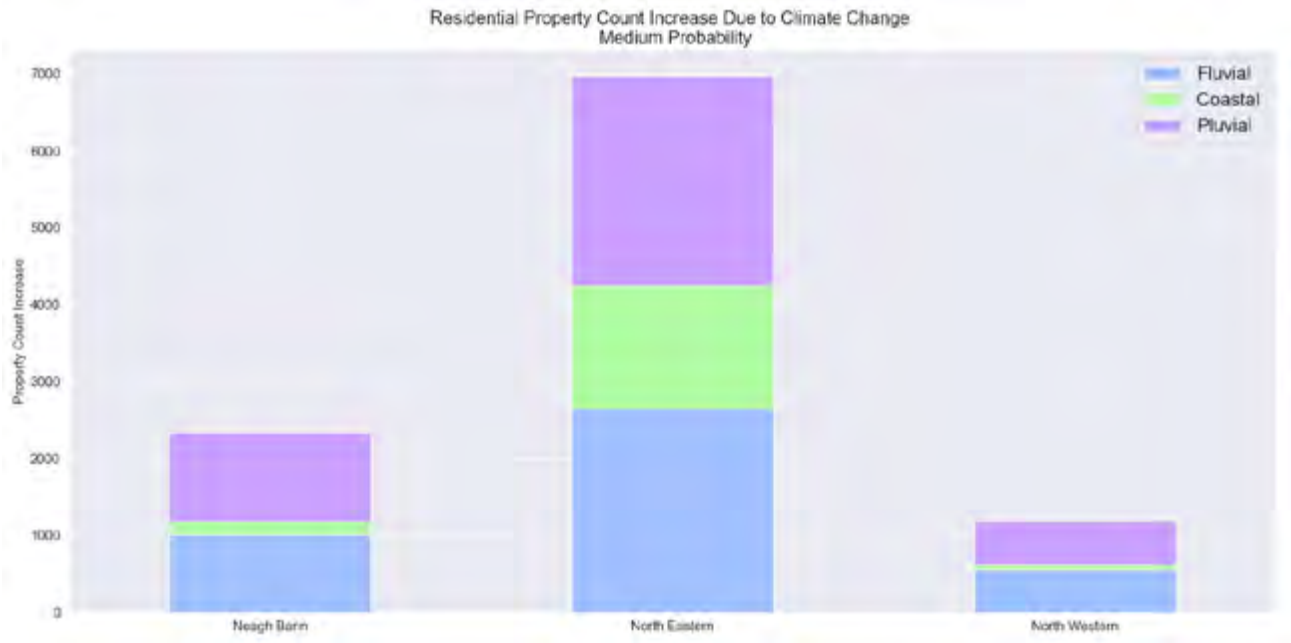


Figure 5.4 Non-Residential Property at risk - Increase in the Medium Probability event by source and by River Basin District

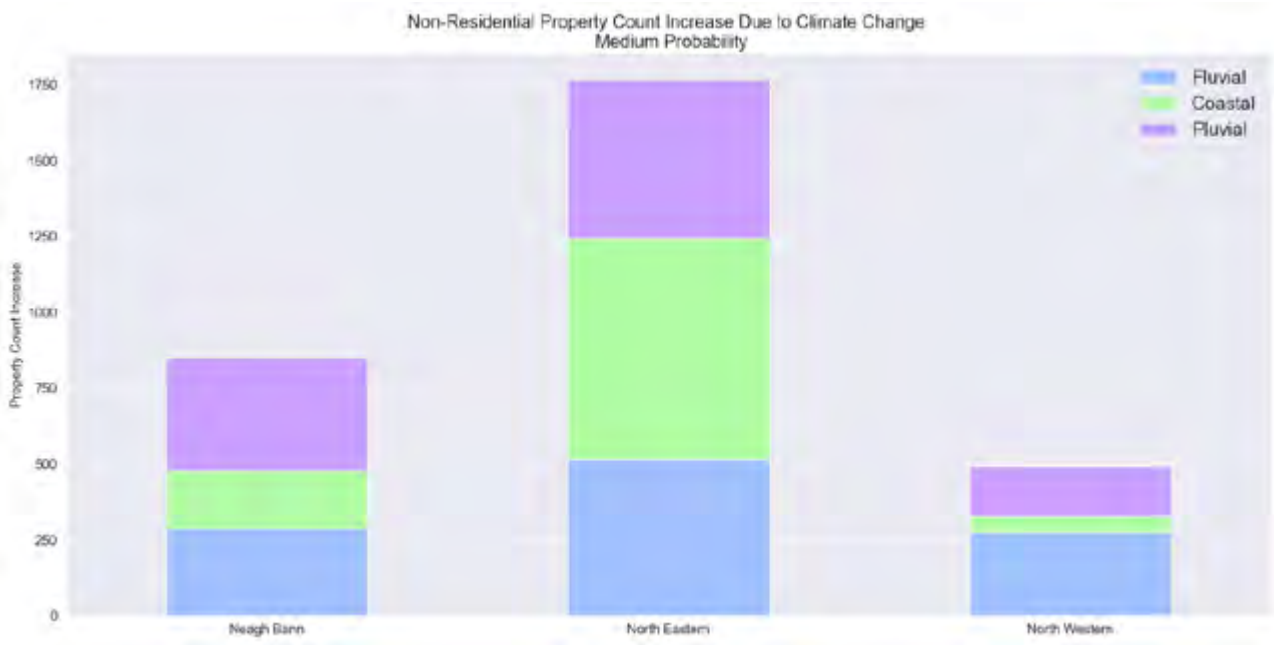


Table 5.3 Northern Ireland FRA Climate Change - Key flood risk metric increase (receptor counts) by Source and River Basin District

Fluvial (Medium Probability)	Neagh Bann	North Eastern	North Western	Totals
Residential Properties	1014	2651	554	4219
Non-Residential Properties	287	516	274	1077
Key Infrastructure	23	41	5	69
IPPC	2	1	0	3
Cultural Heritage	39	38	9	86
Environment	1	8	2	11

Coastal (Medium Probability)	Neagh Bann	North Eastern	North Western	Totals
Residential Properties	168	1605	75	1848
Non-Residential Properties	190	731	54	975
Key Infrastructure	0	24	5	29
IPPC	0	1	0	1
Cultural Heritage	2	52	12	66
Environment	1	2	0	3

Table 5.3 (continued)

Pluvial (Medium Probability)	Neagh Bann	North Eastern	North Western	Totals
Residential Properties	1161	2715	555	4431
Non-Residential Properties	374	521	164	1059
Key Infrastructure	57	80	13	150
IPPC	0	5	0	5
Cultural Heritage	66	91	9	166
Environment	1	3	0	4

5.3 Areas of Potential Significant Flood Risk (APSFR)

Article 9 of the Floods Directive Regulations requires that where the Department updates a PFRA, it shall review and, if necessary, update the identification of APSFR. The identification of APSFR is a key milestone as these are the areas for which the later requirements of the Regulations apply. Areas which are below the threshold determined for APSFR require no further action under the Regulations. However, the flood risk in areas outside APSFR will continue to be managed by the appropriate public body, with responsibility for the flooding, through their existing statutory arrangements.

The NIFRA has identified 12 APSFR and the locations of these areas are highlighted on the map in **Appendix A**. The AAAD in respect of Fluvial, Coastal and Pluvial flooding has been used as a basis to identify APSFR and AAAD value of £1 million has been judged as an appropriate threshold at which a flood risk area should be identified as 'significant' in the context of Northern Ireland.

For each APSFR, the Floods Directive Regulations require that flood hazard and flood risk maps are reviewed and if necessary, updated and made available to the public by December 2019. A Flood Risk Management Plan (FRMP) for the period 2021 – 2027, aimed at managing and mitigating the risk of flooding within APSFR, is to be produced and made available for public consultation by December 2020. The Department has determined a further 9 areas to be 'Transitional Areas of Potential Significant Flood Risk' (TAPSFR). These 9 areas were assessed in the 2011 PFRA as APSFR and have been given this classification to ensure continuity between FRMPs and facilitate implementation of any outstanding commitments arising from delivery of objectives and measures within the 2015 – 2021 FRMPs. The areas are also illustrated on the map at **Appendix A**.

Table 5.4 and **Table 5.5** provide summaries of the key flood risk metrics associated with the designated APSFR and TAPSFR respectively while **Figure 5.5** presents the AAAD by floods source for all APSFR and TAPSFR. In comparison to other APSFR, Belfast is predicted to be the most economically impacted with AAADs of approximately £16m. This compares with Ballymena which is the least economically impacted APSFR with AAADs of approximately £1m. Further key flood risk metric breakdowns of the designated areas are provided in **Appendix B**.

Table 5.4 APSFR Key Flood Risk Metrics

	Fluvial	Coastal	Pluvial	Totals
Total Property Damages (Millions)	£ 8.21	£ 2.76	£ 30.29	£ 41.26
Residential Property Damages (Millions)	£ 3.20	£ 0.70	£ 11.77	£ 15.67
Intangibles (Millions)*	£ 0.23	£ 0.01	£ 0.28	£ 0.52
Non-Residential Property Damages (Millions)	£ 4.78	£ 2.05	£ 18.24	£ 25.07
People at Risk	2825	161	3561	6547
Count Residential	1130	64	1424	2618
Count Non-Residential	236	69	359	664
Count Key Infrastructure	26	6	60	92
Count IPPC	3	1	6	10
Count Cultural Heritage	21	7	50	78
Count Environment	1	0	1	2

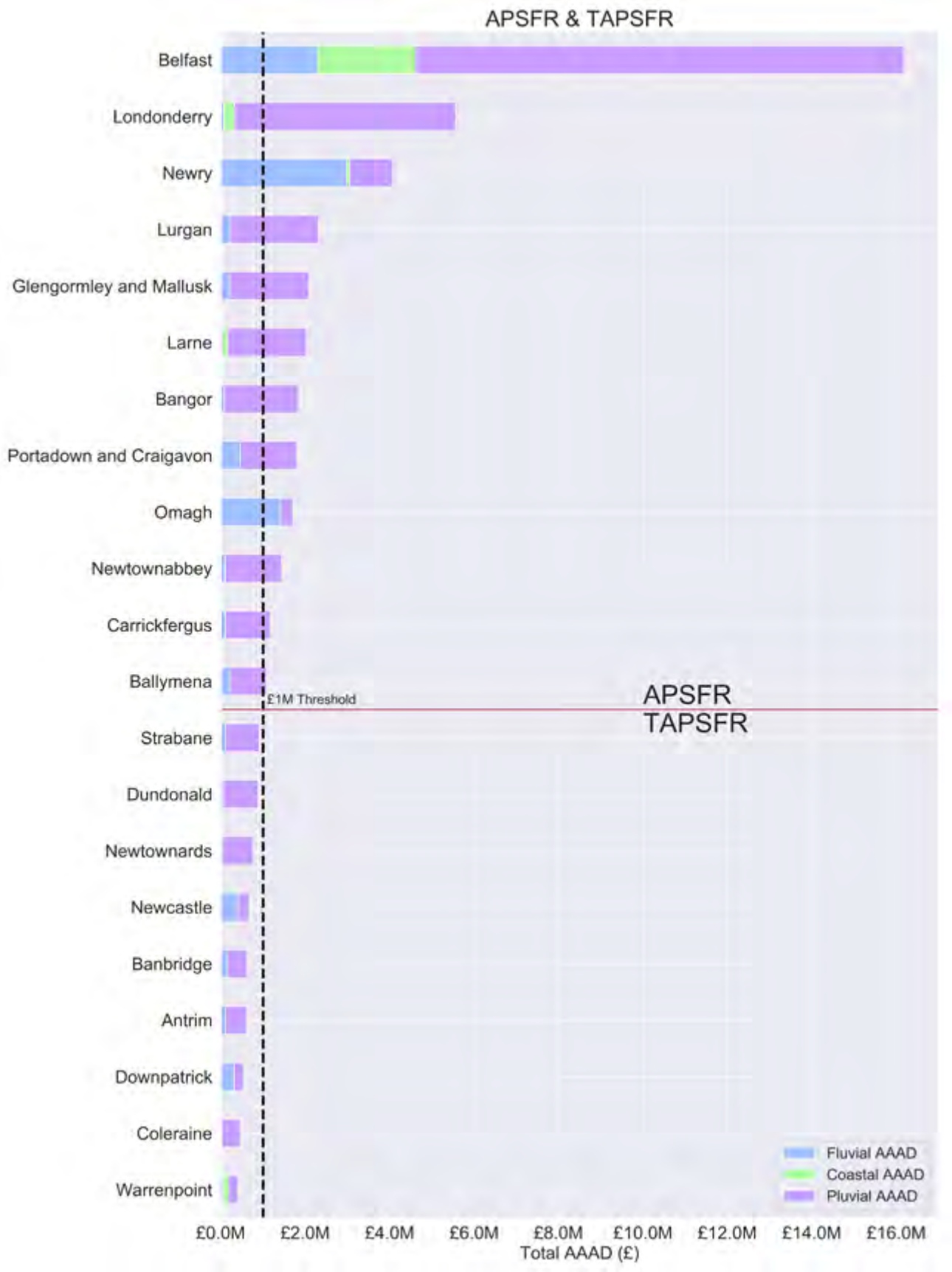
* intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Table 5.5 TAPSFR Key Flood Risk Metrics

	Fluvial	Coastal	Pluvial	Totals
Total Property Damages (Millions)	£ 0.96	£ 0.13	£ 4.48	£ 5.57
Residential Property Damages (Millions)	£ 0.36	£ 0.07	£ 2.20	£ 2.63
Intangibles (Millions)*	£ 0.01	£ -	£ 0.05	£ 0.06
Non-Residential Property Damages (Millions)	£ 0.59	£ 0.06	£ 2.23	£ 2.88
People at Risk	148	10	618	776
Count Residential	59	4	247	310
Count Non-Residential	38	1	79	118
Count Key Infrastructure	4	1	10	15
Count IPPC	0	0	0	0
Count Cultural Heritage	6	1	13	20
Count Environment	0	1	1	2

*intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Figure 5.5 Northern Ireland APSFR/TAPSFR



6 Conclusions

Following review of the 2011 PFRA, the NIFRA 2018 has identified a total of 45 flood risk areas. Out of these, 12 have been identified as APSFR and a further 9 determined TAPSFR to ensure continuity between FRMPs and facilitate implementation of any outstanding commitments arising from delivery of objectives and measures within the 2015 – 2021 FRMPs. For each of the APSFR identified, the Floods Directive Regulations require that flood hazard and flood risk maps are reviewed and if necessary, updated and made available to the public by December 2019. A FRMP for the period 2021 – 2027, aimed at managing and mitigating the risk of flooding within APSFR, is to be produced and made available for public consultation by December 2020.

The NIFRA 2018 demonstrates the Department's commitment to ensuring that flood risk continues to be assessed and managed effectively, taking account of new and updated information and changes in risk. Moving forward, our understanding of flood risk is constantly developing and improving and more detailed fluvial and coastal flood hazard and flood risk maps have been and will continue to be developed to improve prioritisation and decision making in the context of flood risk management.

7 Bibliography

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Appendix A: APSFR and TAPSFR Location Map

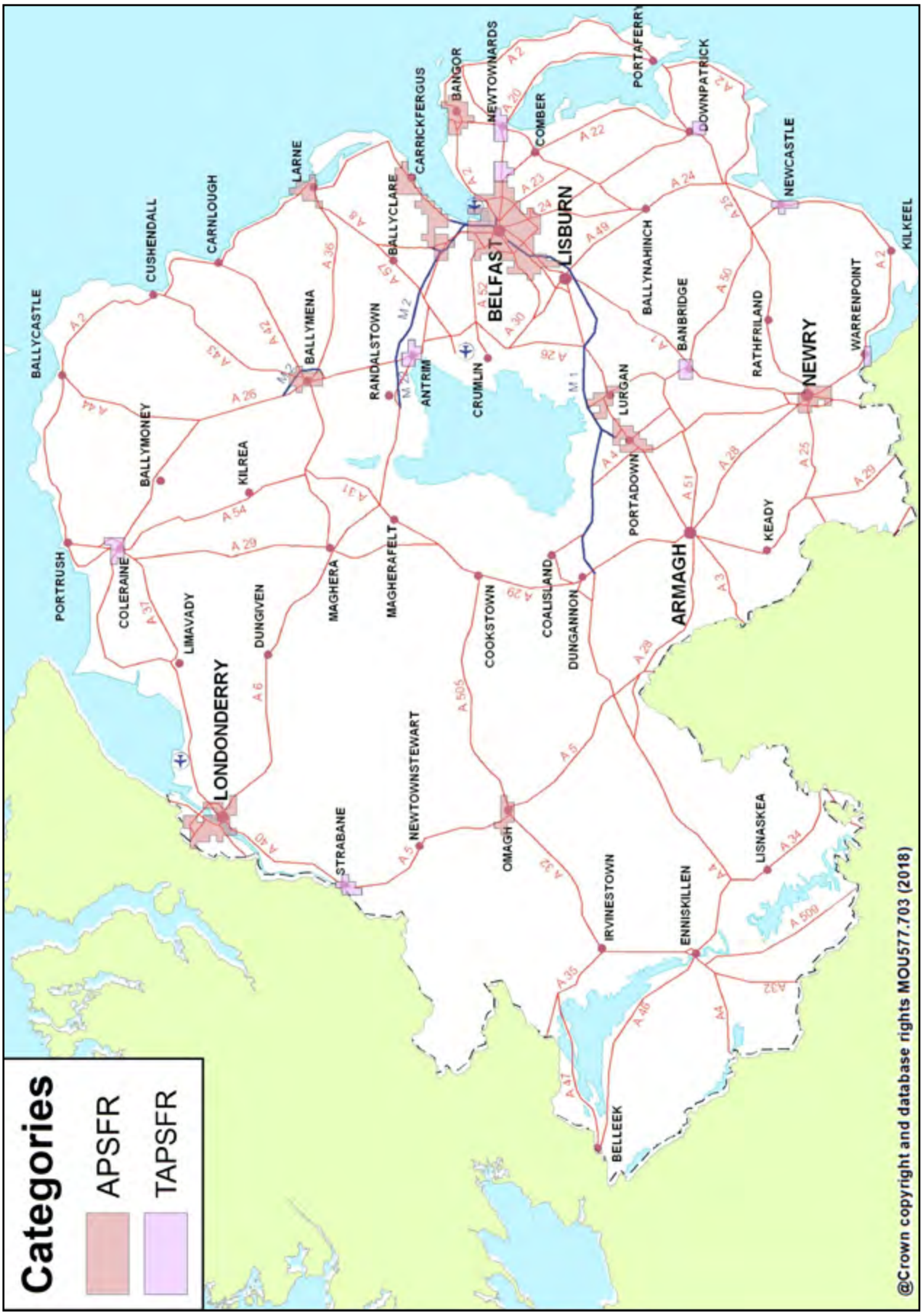


Figure 7.1 Northern Ireland APSFR and TAPSFR Location Map

APPENDIX B: Summary Reports

Table 7.1 Northern Ireland FRA - Key flood risk metrics by Source and River Basin District

Fluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 5.33	£ 3.61	£ 1.75	£ 10.69
Residential Property Damages (Millions)	£ 1.58	£ 2.18	£ 0.56	£ 4.32
Intangibles (Millions)*	£ 0.05	£ 0.21	£ 0.01	£ 0.27
Non-Residential Property Damages (Millions)	£ 3.70	£ 1.22	£ 1.18	£ 6.10
People at Risk	603	2627	129	3359
Count Residential	241	1051	52	1344
Count Non-Residential	158	126	37	321
Count Key Infrastructure	14	18	5	37
Count IPPC	0	2	0	2
Count Cultural Heritage	17	10	3	30
Count Environment	0	1	0	1

Coastal	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 0.21	£ 2.44	£ 0.80	£ 3.45
Residential Property Damages (Millions)	£ 0.08	£ 0.66	£ 0.05	£ 0.79
Intangibles (Millions)*	£ -	£ 0.01	£ -	£ 0.01
Non-Residential Property Damages (Millions)	£ 0.13	£ 1.77	£ 0.75	£ 2.65
People at Risk	10	153	10	173
Count Residential	4	61	4	69
Count Non-Residential	7	55	19	81
Count Key Infrastructure	0	6	1	7
Count IPPC	0	1	0	1
Count Cultural Heritage	0	6	2	8
Count Environment	0	0	0	0

Table 7.1 (continued)

Pluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 11.71	£ 22.03	£ 8.09	£ 41.83
Residential Property Damages (Millions)	£ 4.01	£ 9.61	£ 3.69	£ 17.31
Intangibles (Millions)*	£ 0.09	£ 0.24	£ 0.07	£ 0.40
Non-Residential Property Damages (Millions)	£ 7.61	£ 12.18	£ 4.33	£ 24.12
People at Risk	1163	2996	876	5035
Count Residential	464	1198	351	2013
Count Non-Residential	177	262	107	546
Count Key Infrastructure	27	45	13	85
Count IPPC	0	4	0	4
Count Cultural Heritage	35	31	17	83
Count Environment	0	1	0	1

*intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Figure 7.2 Total AAAD by River Basin District

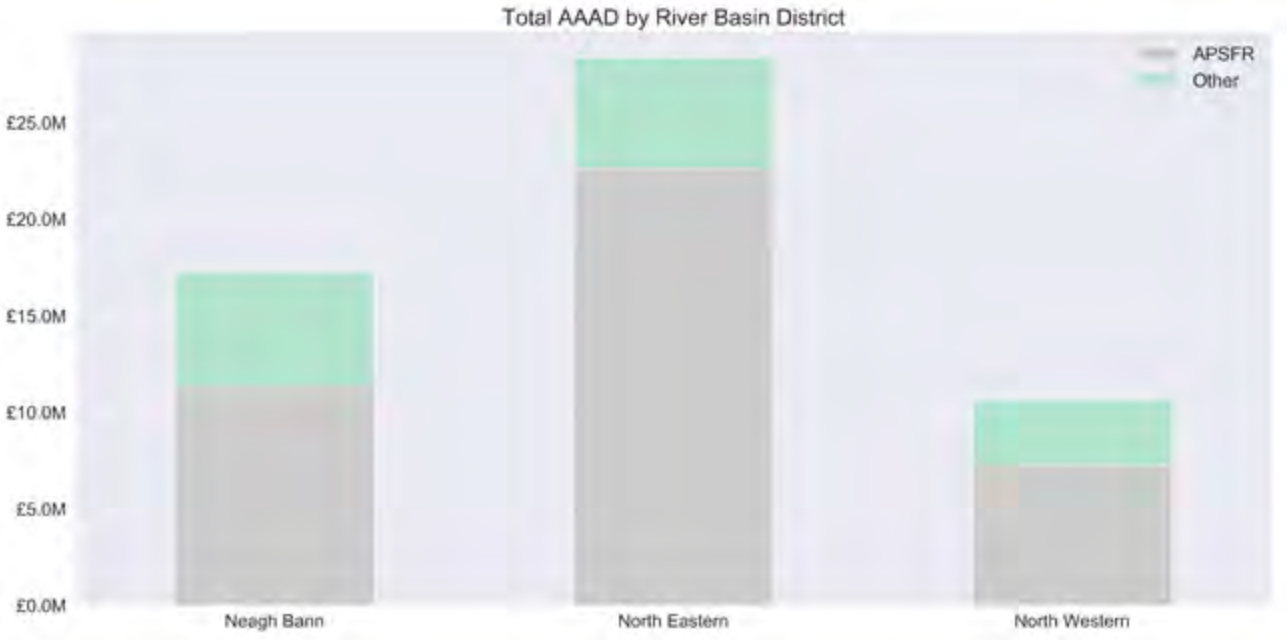


Figure 7.2 presents flood risk in terms of predicted AAADs for each of the three RBDs, and between APSFR and other FRA. Whilst the APSFR category refers to the 12 areas in Northern Ireland with estimated AAADs in excess of £1.0 million, the category "other" refers to the remaining 9 TAPSFR and 24 FRA.

The North Eastern RBD accounts for 50% of total damages across the Northern Ireland FRAs owing to the elevated population densities and urban concentrations particularly around Belfast and Lisburn. The largest FRA in the North Eastern RBD is Belfast with an estimated AAAD that accounts for 28% of total AAADs across Northern Ireland's 45 FRAs and 61% within its respective RBD. The illustration shows that identified APSFR capture the majority of the predicted flood risk in terms of damages within each RBD.

It is noted that the damages from pluvial flooding are the most significant in each RBD. As discussed in the main body of the report, the pluvial flood mapping used in the analysis is strategic. The second most dominant source of flooding in the Neagh Bann RBD is fluvial. It is predicted to have greater economic impacts than in the North Eastern RBD. However, the North Eastern RBD is the most affected by coastal flooding, likely due to the fact that its coastline is the longest of all three RBDs. The North Western RBD is the least affected of the three and its main FRA is Londonderry (designated as APSFR) with AAADs accounting for over 52% of the total AAADs in its respective RBD.

Table 7.2 and **Table 7.3** present the annualised average flood risk metrics for the 12 APSFR and 9 TAPSFR respectively.

Table 7.2 Northern Ireland APSFR - Key Flood Risk Metrics by Source and River Basin District.

Fluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 4.10	£ 2.61	£ 1.49	£ 8.21
Residential Property Damages (Millions)	£ 0.82	£ 1.98	£ 0.40	£ 3.20
Intangibles (Millions)*	£ 0.03	£ 0.19	£ 0.01	£ 0.23
Non-Residential Property Damages (Millions)	£ 3.25	£ 0.45	£ 1.08	£ 4.78
People at Risk	415	2320	90	2825
Count Residential	166	928	36	1130
Count Non-Residential	117	85	34	236
Count Key Infrastructure	9	14	3	26
Count IPPC	1	2	0	3
Count Cultural Heritage	11	8	2	21
Count Environment	0	1	0	1

Table 7.2 (continued)

Coastal	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 0.08	£ 2.44	£ 0.26	£ 2.78
Residential Property Damages (Millions)	£ -	£ 0.66	£ 0.04	£ 0.70
Intangibles (Millions)*	£ -	£ 0.01	£ -	£ 0.01
Non-Residential Property Damages (Millions)	£ 0.08	£ 1.77	£ 0.22	£ 2.07
People at Risk	0	153	8	161
Count Residential	0	61	3	64
Count Non-Residential	6	55	8	69
Count Key Infrastructure	0	5	1	6
Count IPPC	0	1	0	1
Count Cultural Heritage	0	5	2	7
Count Environment	0	0	0	0

Pluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 7.17	£ 17.60	£ 5.52	£ 30.29
Residential Property Damages (Millions)	£ 1.98	£ 7.39	£ 2.40	£ 11.77
Intangibles (Millions)*	£ 0.05	£ 0.19	£ 0.04	£ 0.28
Non-Residential Property Damages (Millions)	£ 5.14	£ 10.02	£ 3.08	£ 18.24
People at Risk	598	2423	540	3561
Count Residential	239	969	216	1424
Count Non-Residential	92	204	63	359
Count Key Infrastructure	17	34	9	60
Count IPPC	2	4	0	6
Count Cultural Heritage	16	23	11	50
Count Environment	0	1	0	1

*intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Table 7.3 Northern Ireland TAPSFR - Key Flood Risk Metrics by Source and River Basin District.

Fluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 0.34	£ 0.51	£ 0.11	£ 0.96
Residential Property Damages (Millions)	£ 0.13	£ 0.12	£ 0.11	£ 0.36
Intangibles (Millions)*	£ -	£ 0.01	£ -	£ 0.01
Non-Residential Property Damages (Millions)	£ 0.21	£ 0.38	£ -	£ 0.59
People at Risk	53	70	25	148
Count Residential	21	28	10	59
Count Non-Residential	21	16	1	38
Count Key Infrastructure	3	1	0	4
Count IPPC	0	0	0	0
Count Cultural Heritage	5	1	0	6
Count Environment	0	0	0	0

Coastal	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 0.13	£ -	£ -	£ 0.13
Residential Property Damages (Millions)	£ 0.07	£ -	£ -	£ 0.07
Intangibles (Millions)*	£ -	£ -	£ -	£ -
Non-Residential Property Damages (Millions)	£ 0.06	£ -	£ -	£ 0.06
People at Risk	10	0	0	10
Count Residential	4	0	0	4
Count Non-Residential	1	0	0	1
Count Key Infrastructure	0	1	0	1
Count IPPC	0	0	0	0
Count Cultural Heritage	0	1	0	1
Count Environment	0	1	0	1

Table 7.3 (continued)

Pluvial	Neagh Bann	North Eastern	North Western	Totals
Total Property Damages (Millions)	£ 1.64	£ 2.05	£ 0.79	£ 4.48
Residential Property Damages (Millions)	£ 0.74	£ 1.10	£ 0.36	£ 2.20
Intangibles (Millions)*	£ 0.02	£ 0.02	£ 0.01	£ 0.05
Non-Residential Property Damages (Millions)	£ 0.88	£ 0.93	£ 0.42	£ 2.23
People at Risk	245	270	103	618
Count Residential	98	108	41	247
Count Non-Residential	33	28	18	79
Count Key Infrastructure	5	4	1	10
Count IPPC	0	0	0	0
Count Cultural Heritage	9	2	2	13
Count Environment	0	1	0	1

*intangible damages take into account the stress or inconvenience of moving elsewhere whilst a home is repaired after a flood event. For the NIFRA 2018, a constant £200 economic impact per residential property has been assumed.

Northern Ireland APSFR Climate Change Analysis

Following the analysis undertaken on NI's identified 45 FRAs, a climate change analysis focusing on the medium probability event for each flood source has been undertaken for APSFR. The adverse effects of flooding due to climate change in the future are shown in **Figure 7.3** and **Figure 7.4**. This gives a better understanding of the vulnerability of each APSFR to climate change.

Figure 7.3 APSFR Climate Change Analysis of "at risk" Residential Property Increases

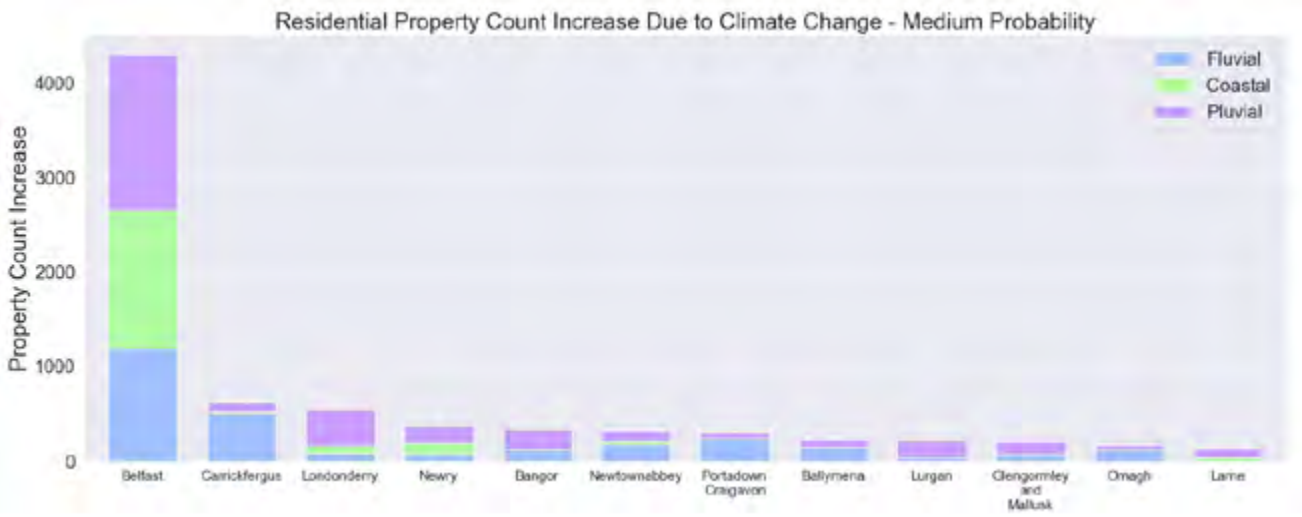
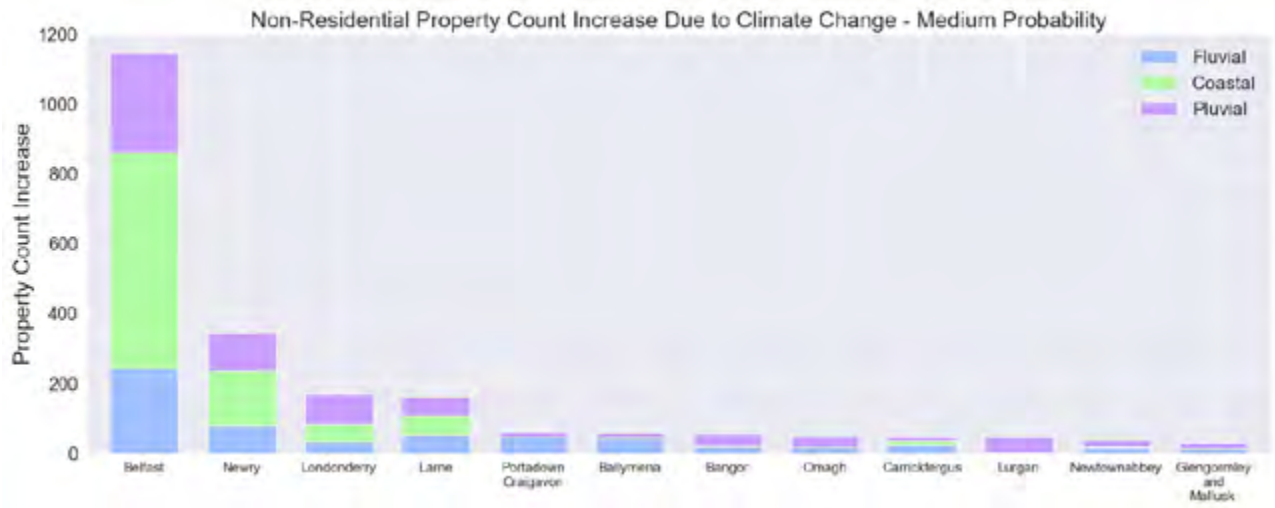


Figure 7.4 APSFR Climate Change Analysis of "at risk" Non-Residential Property Increases



Northern Ireland TAPSFR Climate Change Analysis

Following the analysis undertaken on NI's identified 45 FRAs, a climate change analysis focusing on the medium probability event for each flood source has been undertaken for TAPSFR. The adverse effects of flooding due to climate change in the future are shown in **Figure 7.5** and **Figure 7.6**. This gives a better understanding of the vulnerability of each TAPSFR to climate change.

Figure 7.5 TAPSFR Climate Change Analysis of "at risk" Residential Property Increases

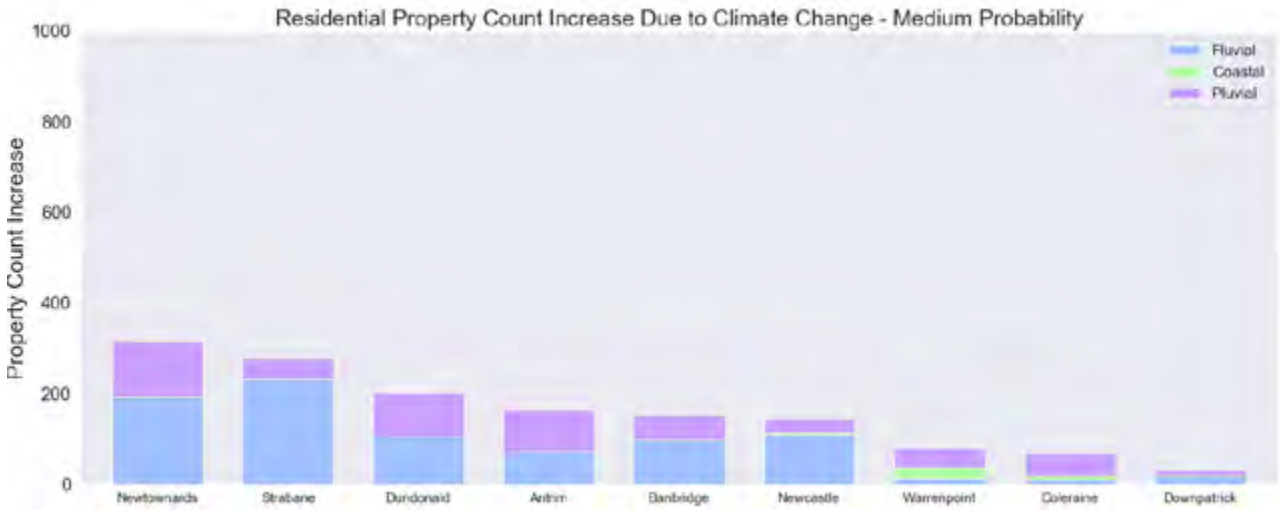
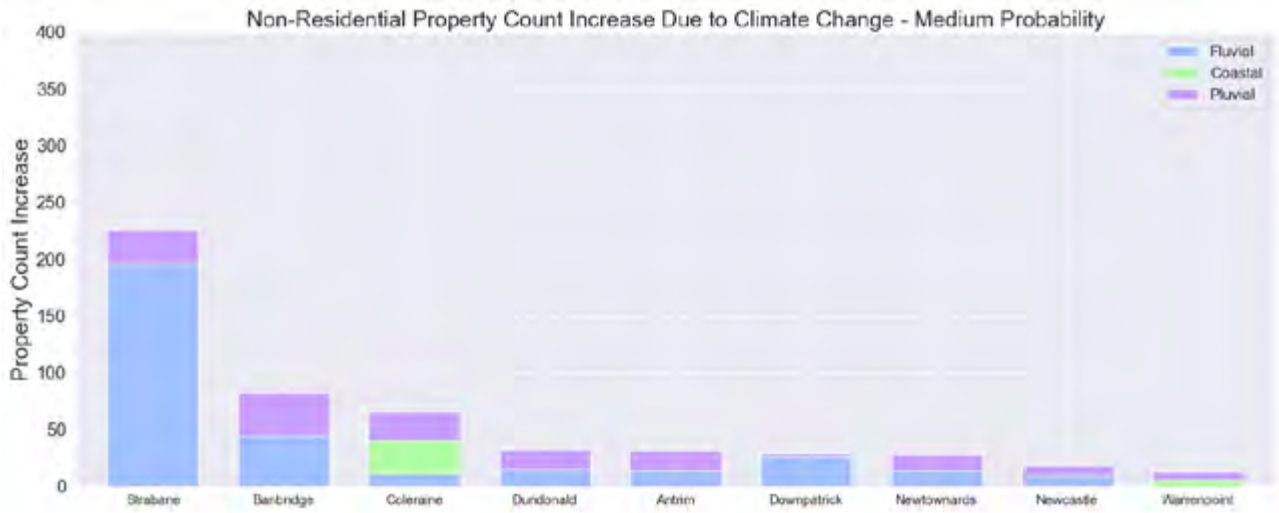


Figure 7.6 TAPSFR Climate Change Analysis of "at risk" Non-Residential Property Increases

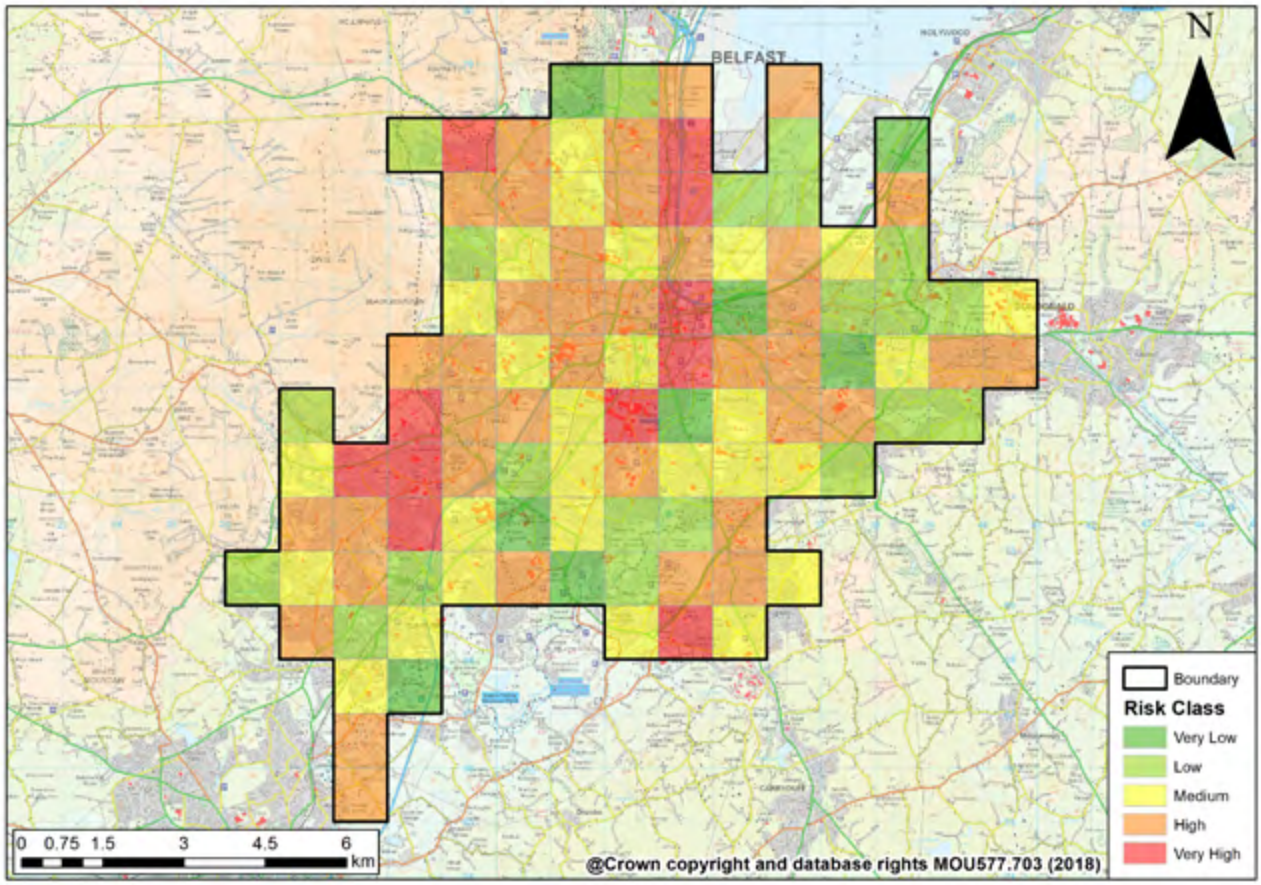


APPENDIX C: APSFR and TAPSFR Summary Reports

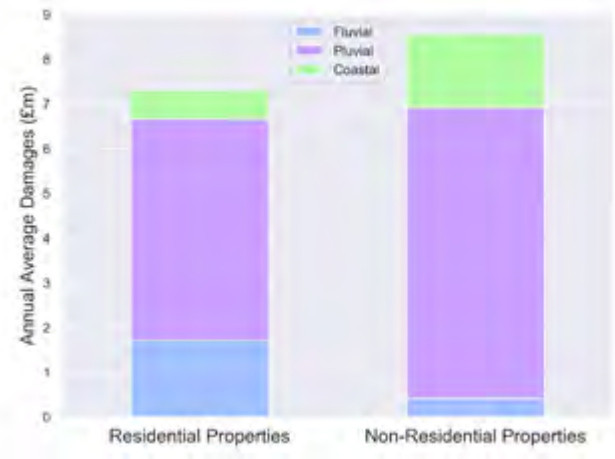
RBD	Area Name	Area (km2)	Designation
North Eastern	Belfast	105	APSFR

Summary

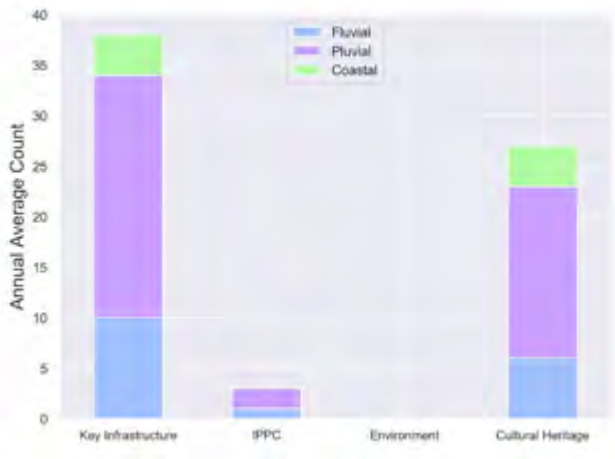
Belfast is the largest APSFR in Northern Ireland. Situated in the North Eastern River Basin District, it is at risk of flooding from pluvial, fluvial and coastal sources. Receptors at risk include numerous homes and businesses. Historically, Belfast has been subject to a number of significant flood events. Most recently in January 2014, the highest tidal surge was recorded in Belfast Harbour. In June 2012, heavy rain affected over 1,500 homes and businesses.



Property at risk by source



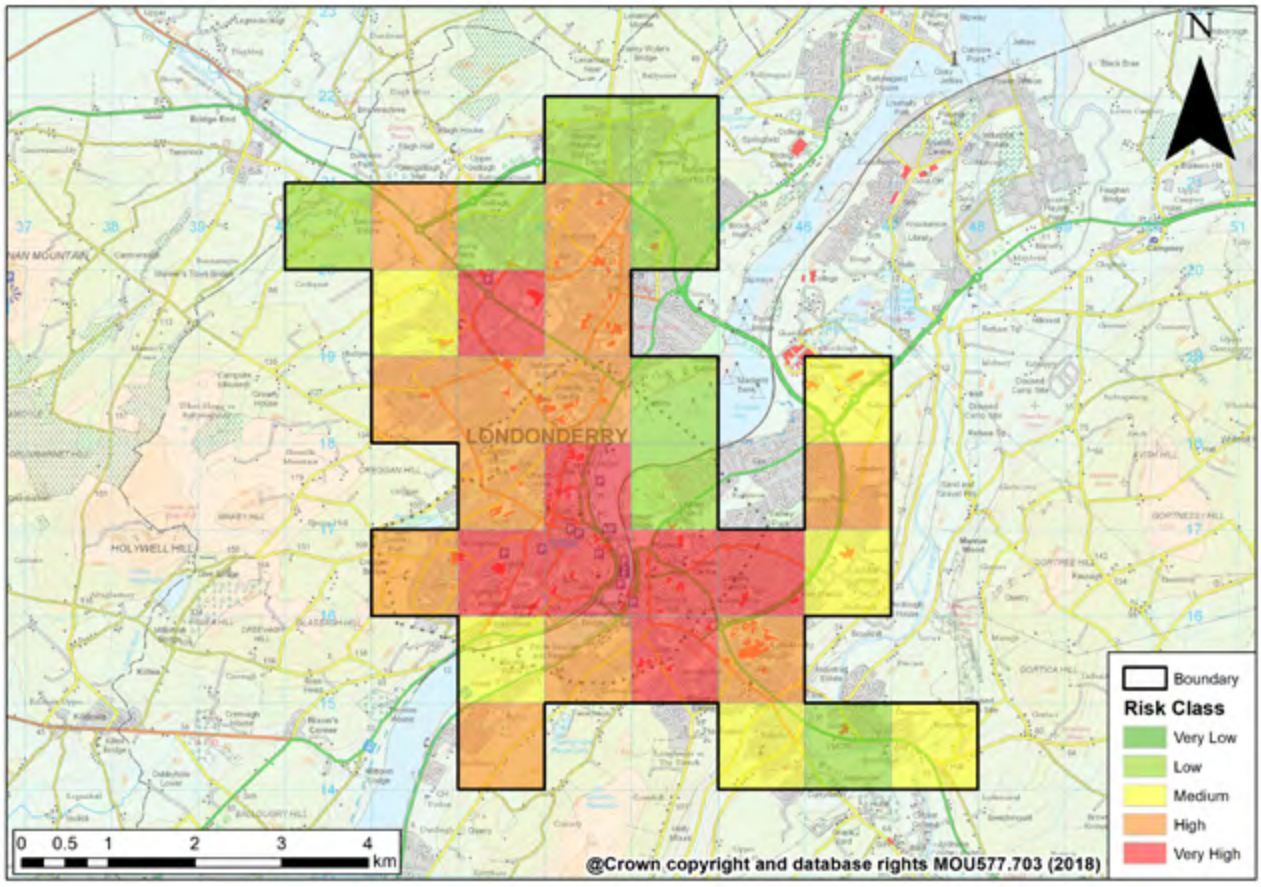
Other receptors at risk by source



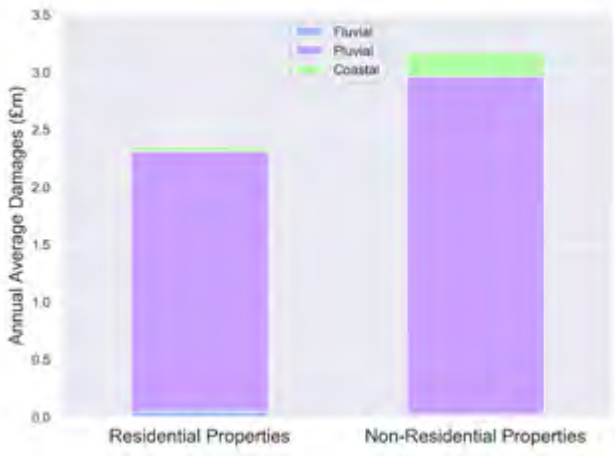
RBD	Area Name	Area (km2)	Designation
North Western	Londonderry	33	APSFR

Summary

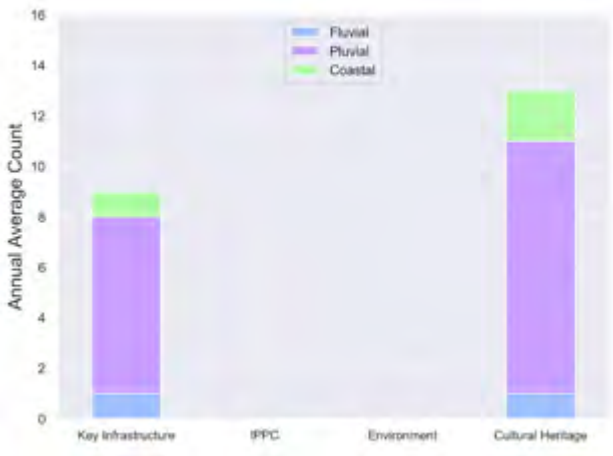
Londonderry is situated in the North Western River Basin District. Flood risk stems from fluvial, pluvial and coastal sources which could adversely impact people and property in the area. The most recent significant flood occurrence in the Derry area was in August 2017 due to intense heavy rainfall.



Property at risk by source



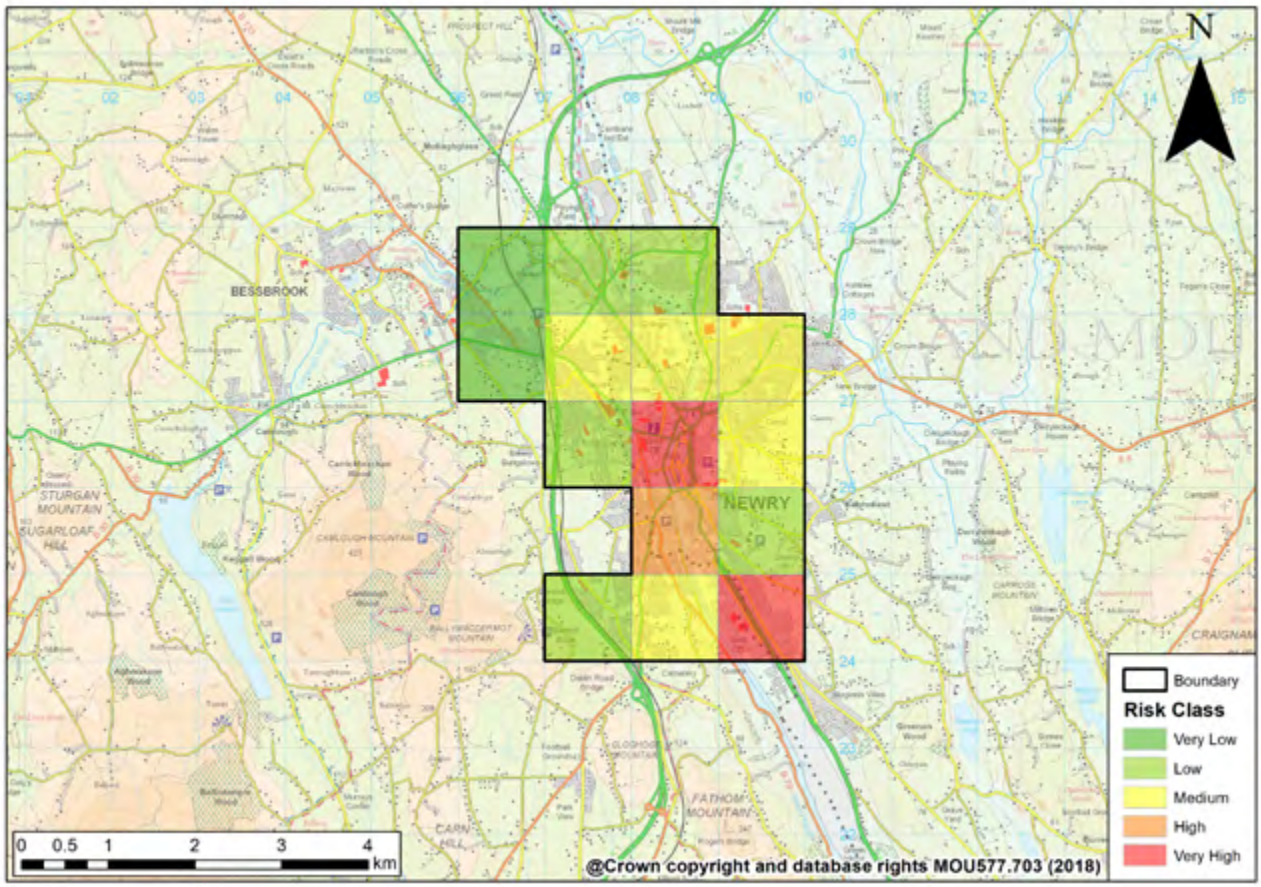
Other receptors at risk by source



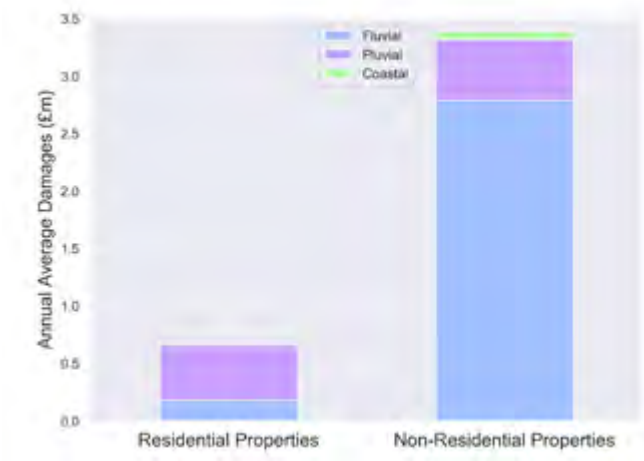
RBD	Area Name	Area (km2)	Designation
Neagh Bann	Newry	15	APSFR

Summary

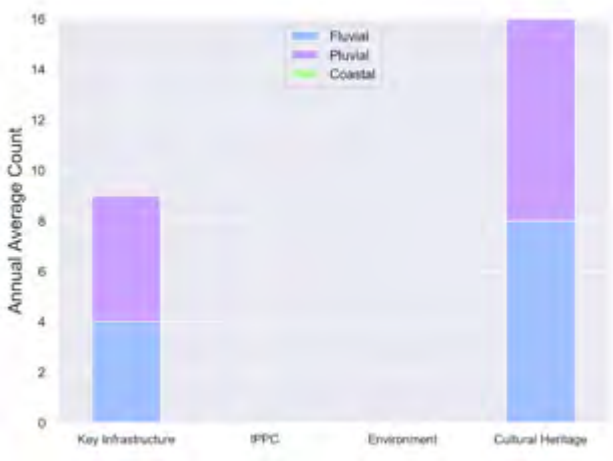
Newry is situated in the Neagh Bann River Basin District. It is at risk of flooding from fluvial, pluvial and coastal sources which could adversely impact on people and property in the area. Newry has significant defences to protect against flooding from fluvial and coastal sources.



Property at risk by source



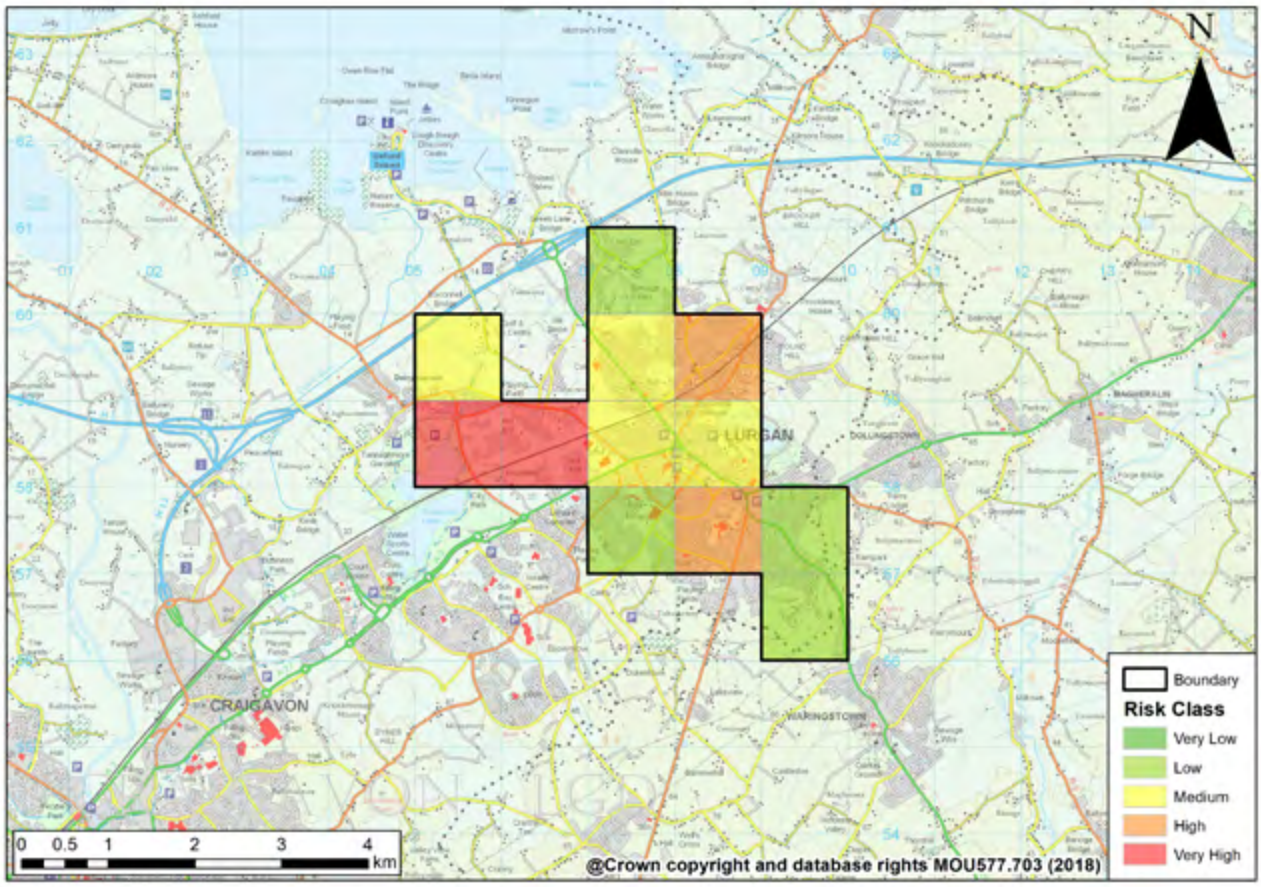
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Lurgan	12	APSFR

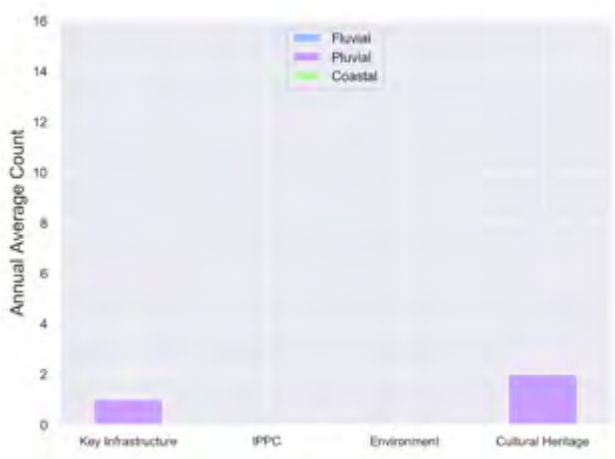
Summary

Lurgan is situated in the Neagh Bann River Basin District. It is at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area.



Property at risk by source

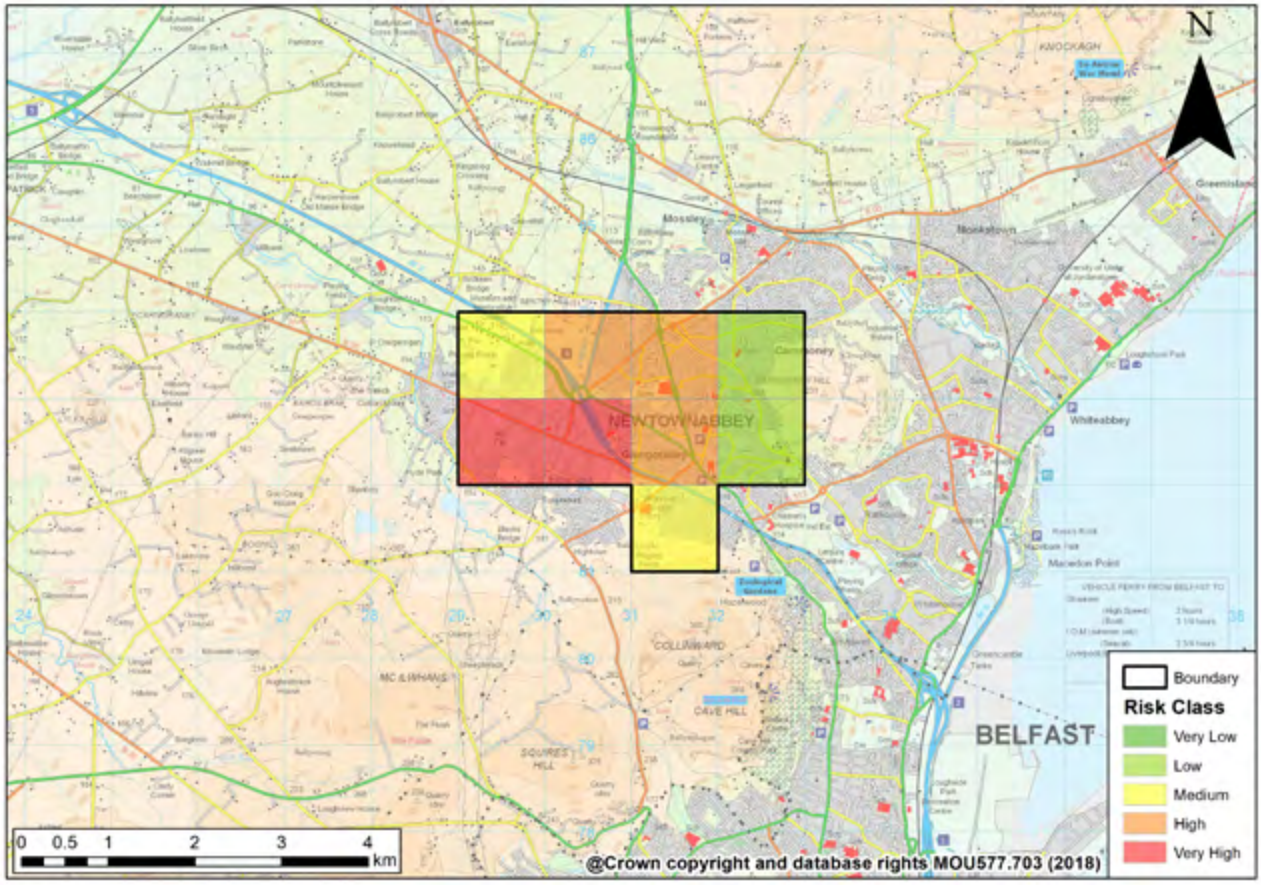
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Glengormley and Mallusk	9	APSFR

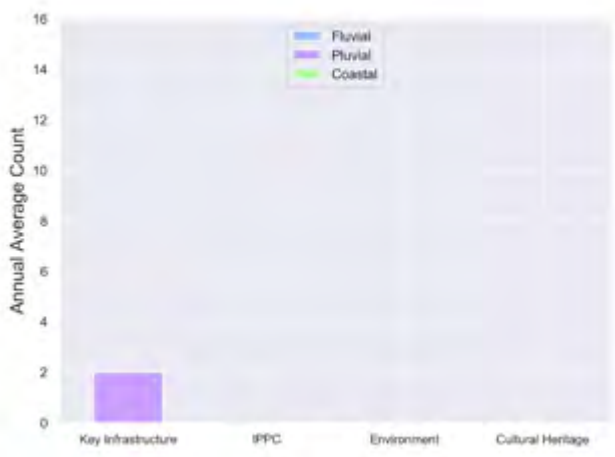
Summary

Glengormley and Mallusk are situated in the Neagh Bann River Basin District. These areas are at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area.



Property at risk by source

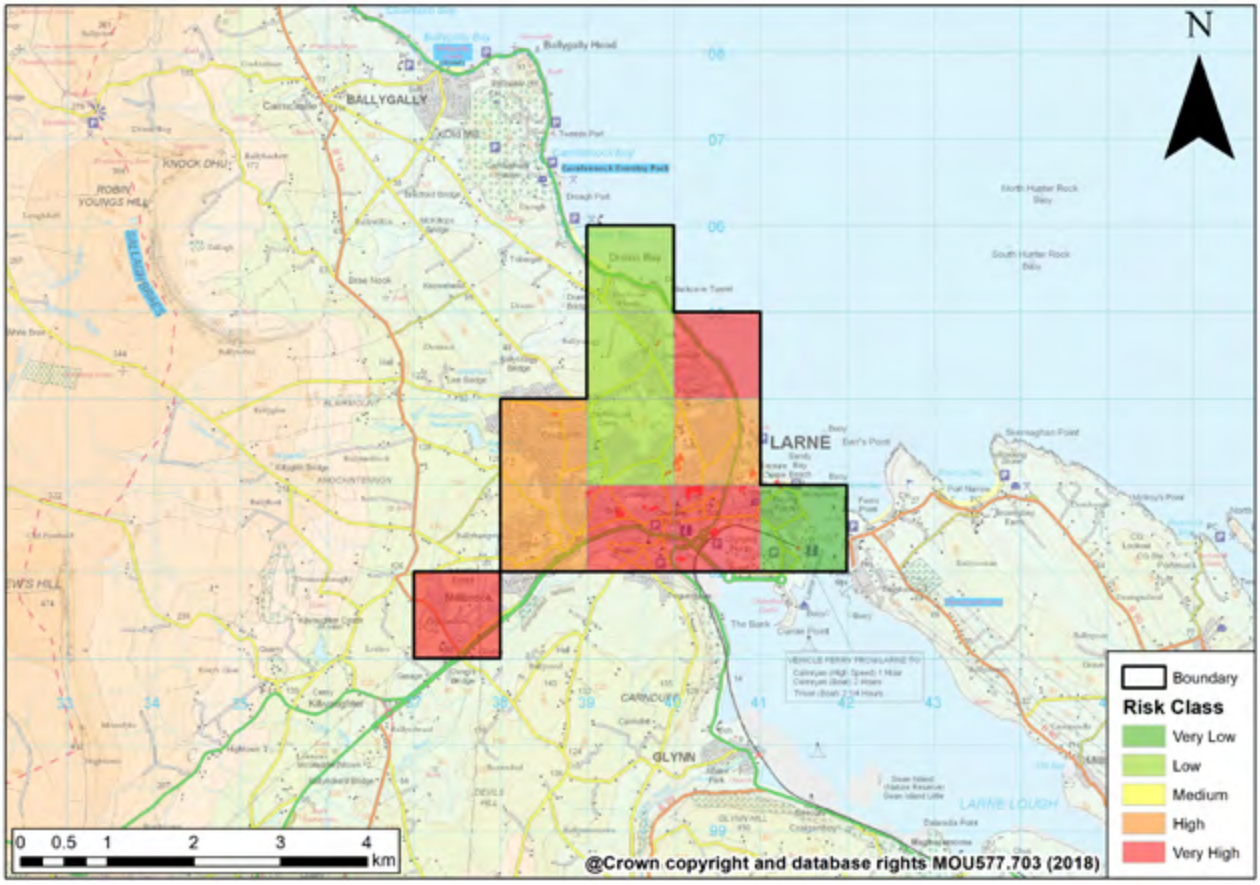
Other receptors at risk by source



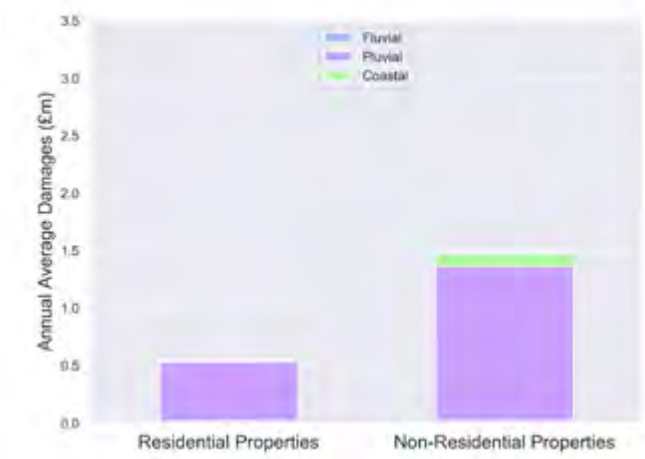
RBD	Area Name	Area (km2)	Designation
North Eastern	Larne	11	APSFR

Summary

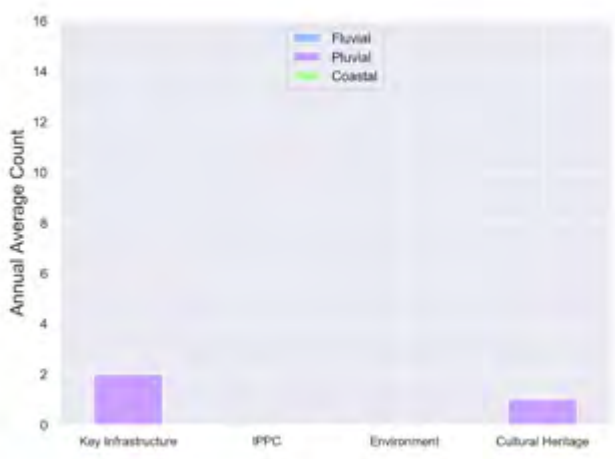
Larne is a coastal town situated in the North Eastern River Basin District. It is at risk of flooding from fluvial, pluvial and coastal sources which could adversely impact on people and property in the area.



Property at risk by source



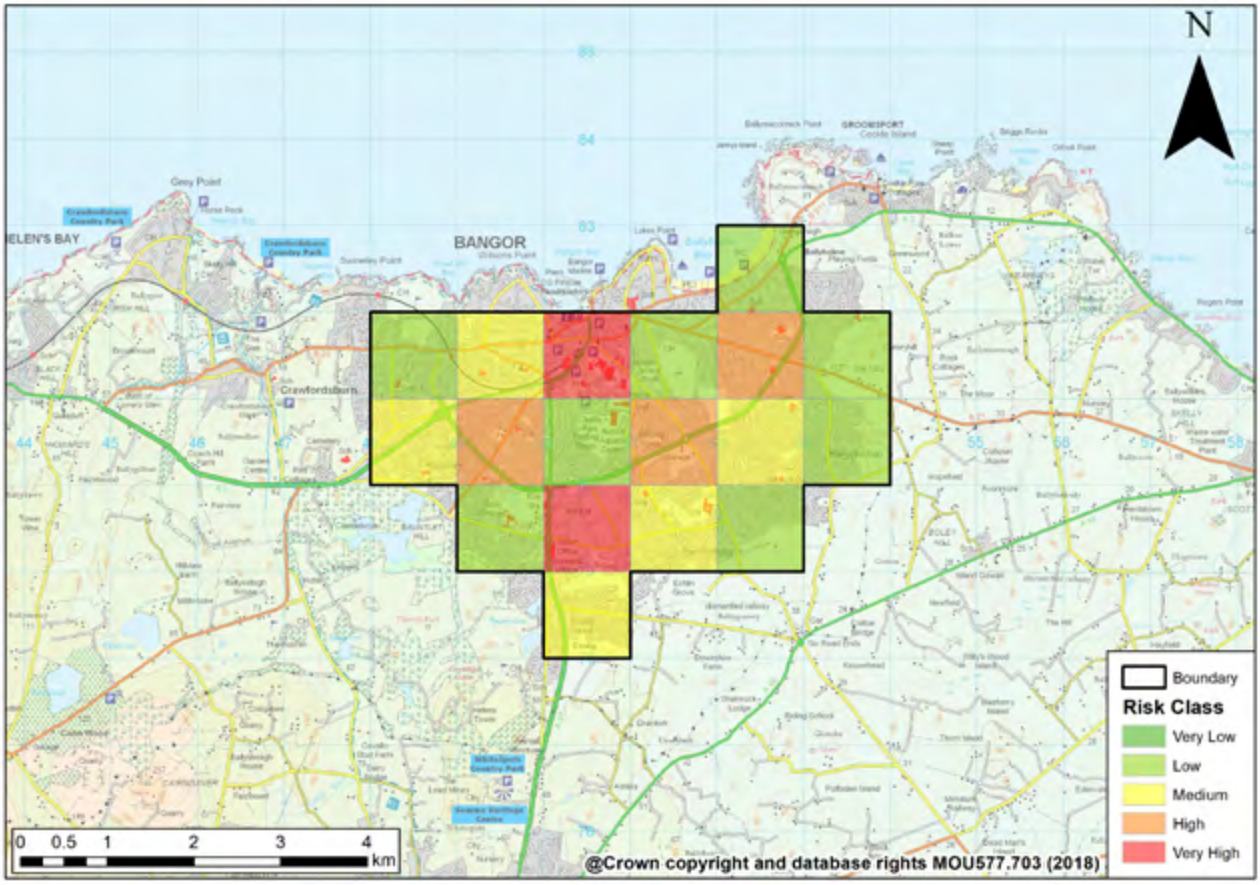
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Bangor	18	APSFR

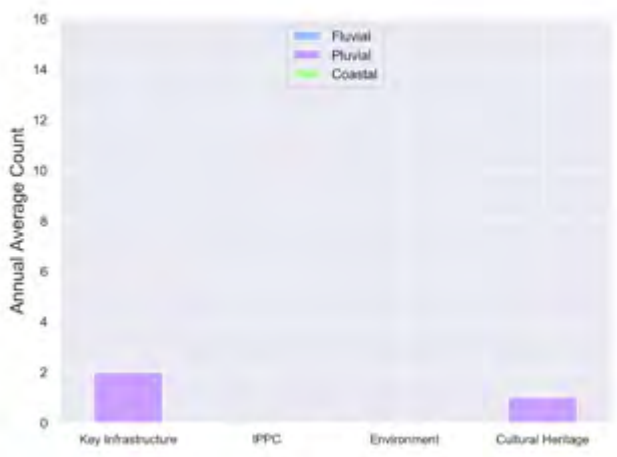
Summary

Bangor is situated in the North Eastern River Basin District. While it is a coastal town, the main risk of flooding arises from pluvial and fluvial sources which could adversely impact on people and property in the area.



Property at risk by source

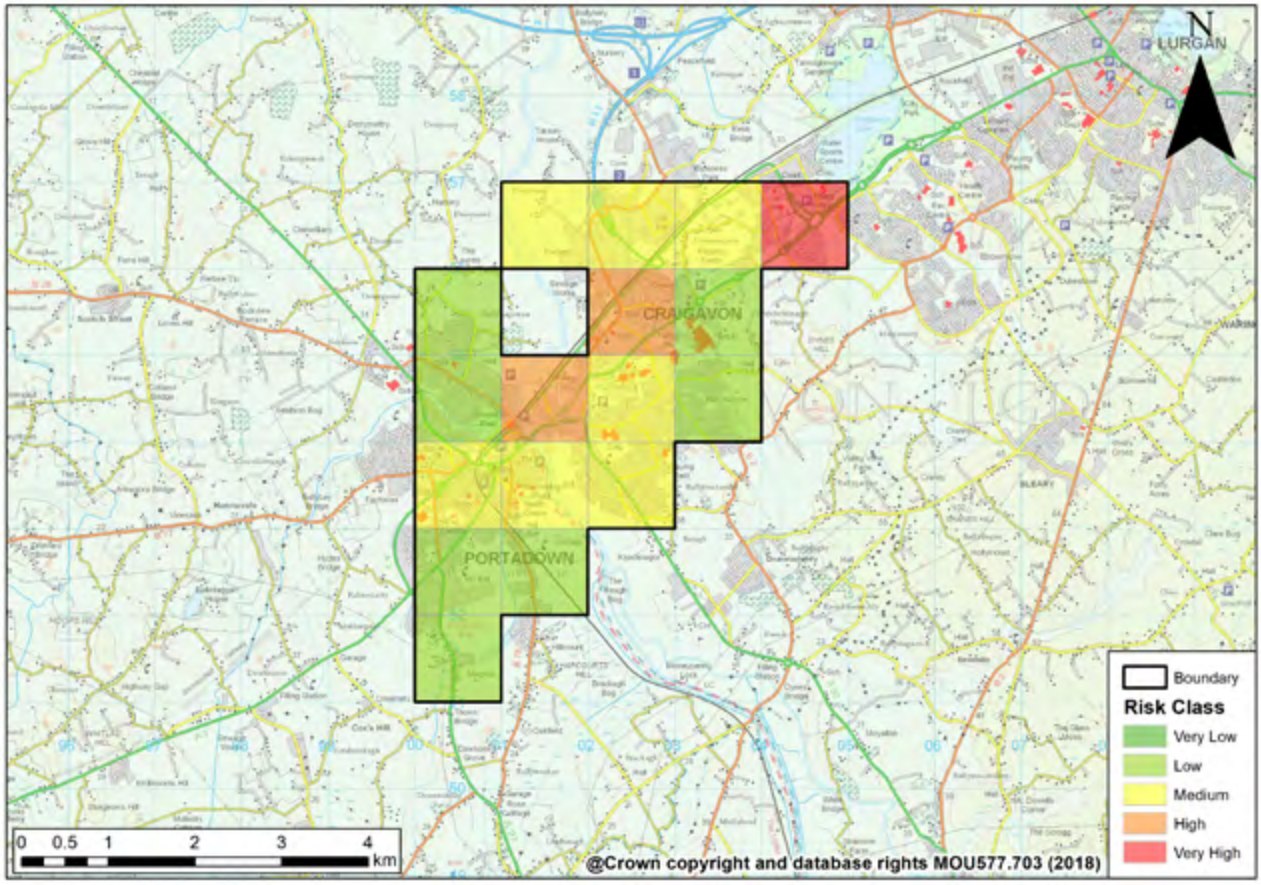
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Portadown and Craigavon	17	APSFR

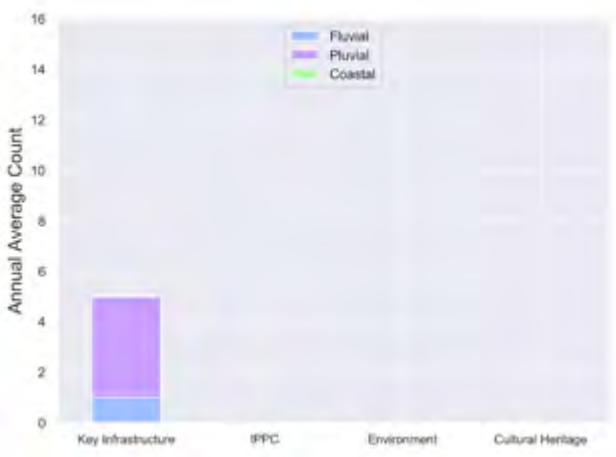
Summary

Portadown and Craigavon are situated in the Neagh Bann River Basin District. These areas are at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area.



Property at risk by source

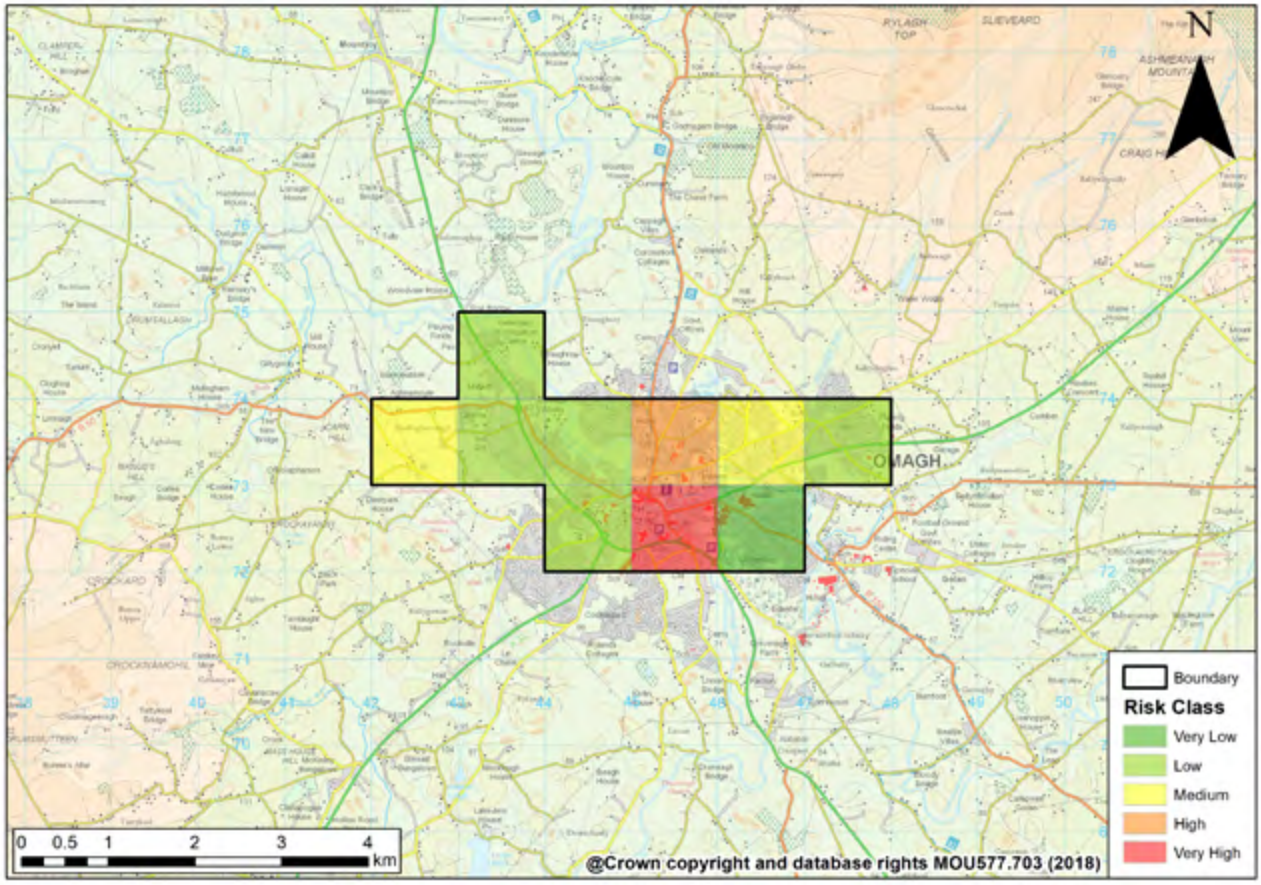
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Western	Omagh	10	APSFR

Summary

Omagh is situated in the North Western River Basin District. It is at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area. Omagh has significant defences to protect against flooding from fluvial sources.



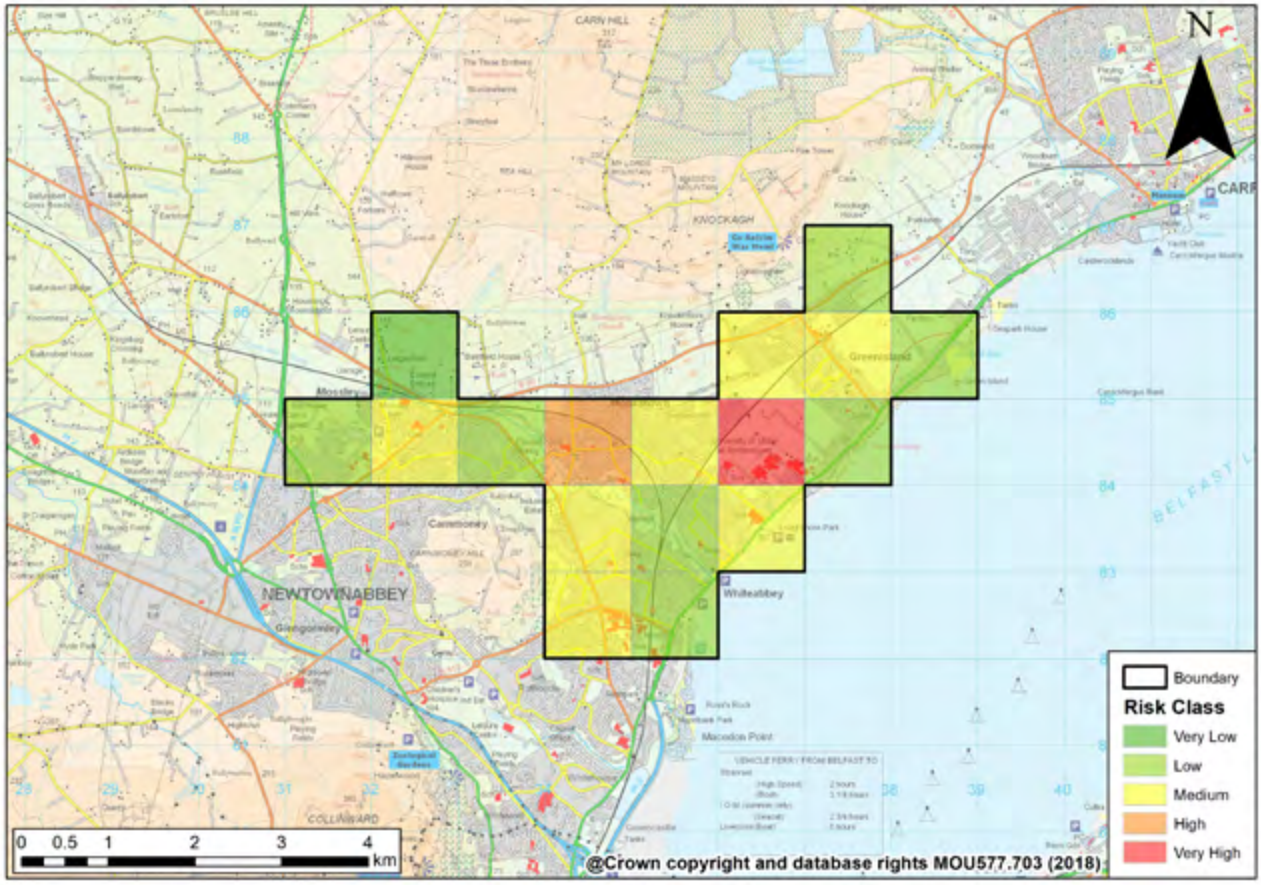
Property at risk by source

Other receptors at risk by source

RBD	Area Name	Area (km2)	Designation
North Eastern	Newtownabbey	17	APSFR

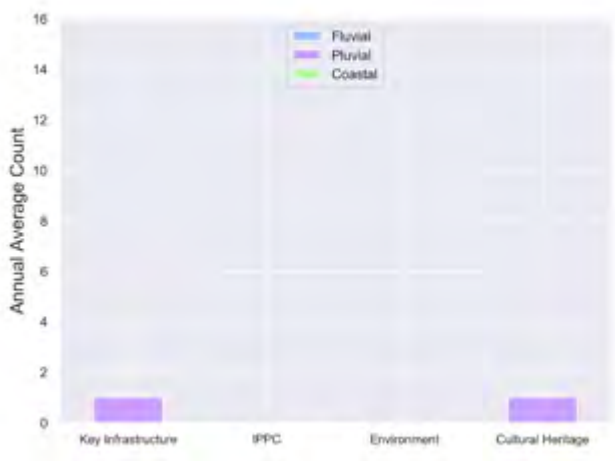
Summary

Newtownabbey is situated in the North Eastern River Basin District. It is at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area.



Property at risk by source

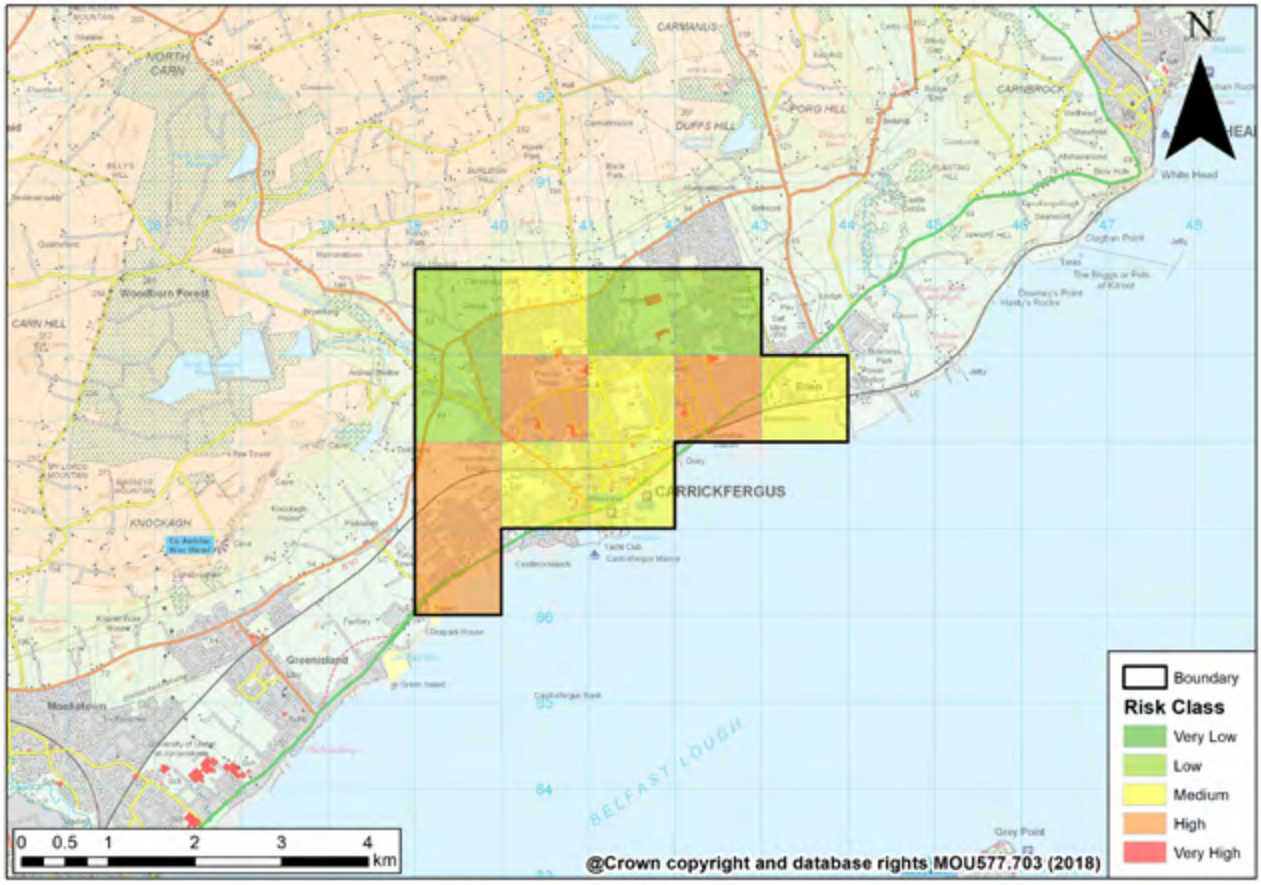
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Carrickfergus	13	APSFR

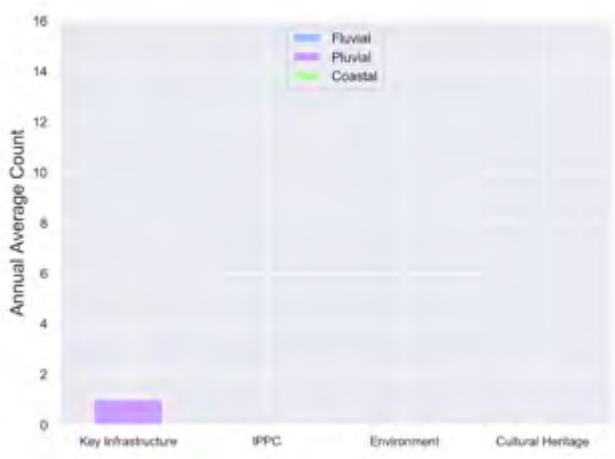
Summary

Carrickfergus is situated in the North Eastern River Basin District. While it is a coastal town, the main risk of flooding arises from pluvial and fluvial sources which could adversely impact on people and property in the area.



Property at risk by source

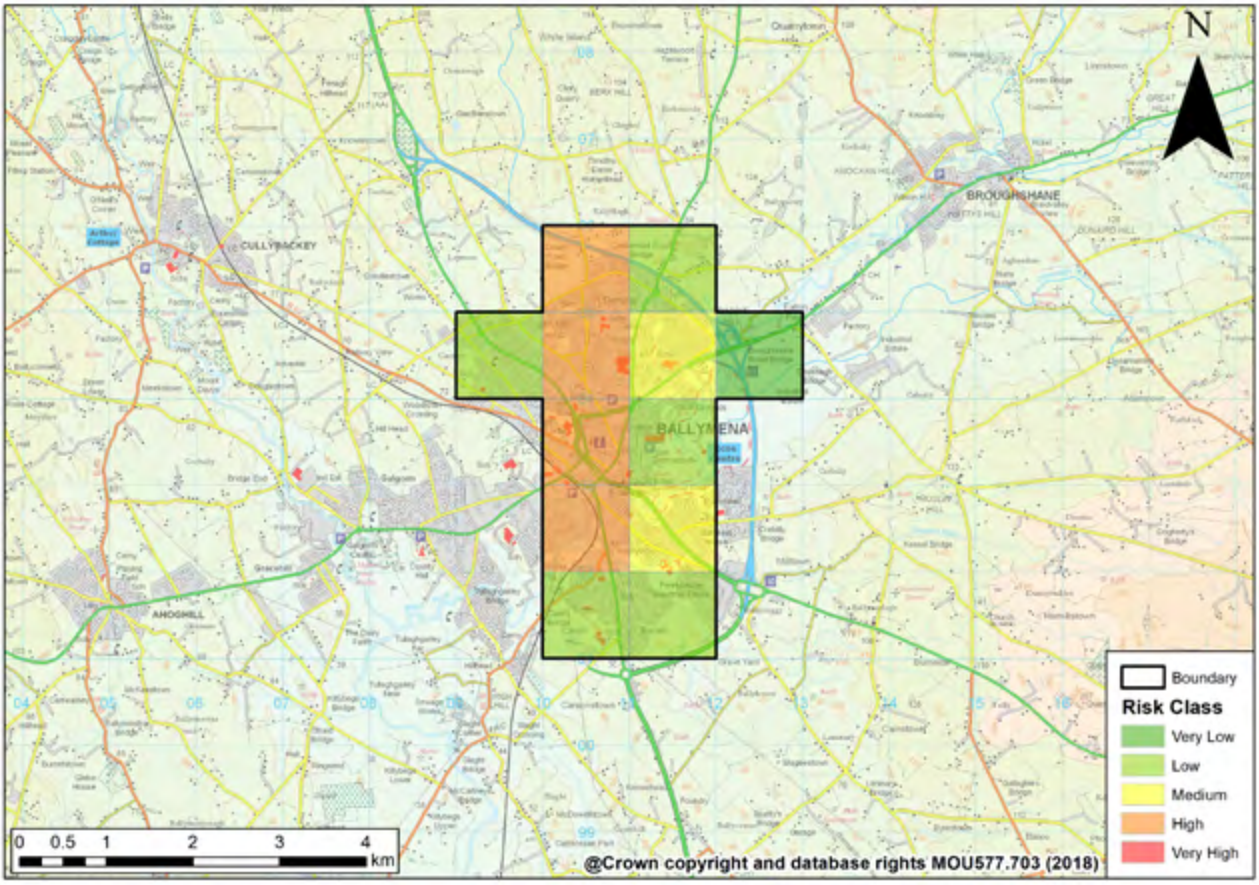
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Ballymena	12	APSFR

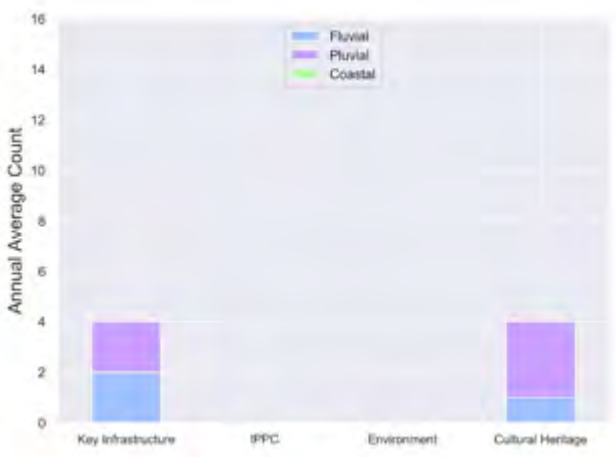
Summary

Ballymena is situated in the Neagh Bann River Basin District. It is at risk of flooding from fluvial and pluvial sources which could adversely impact on people and property in the area.



Property at risk by source

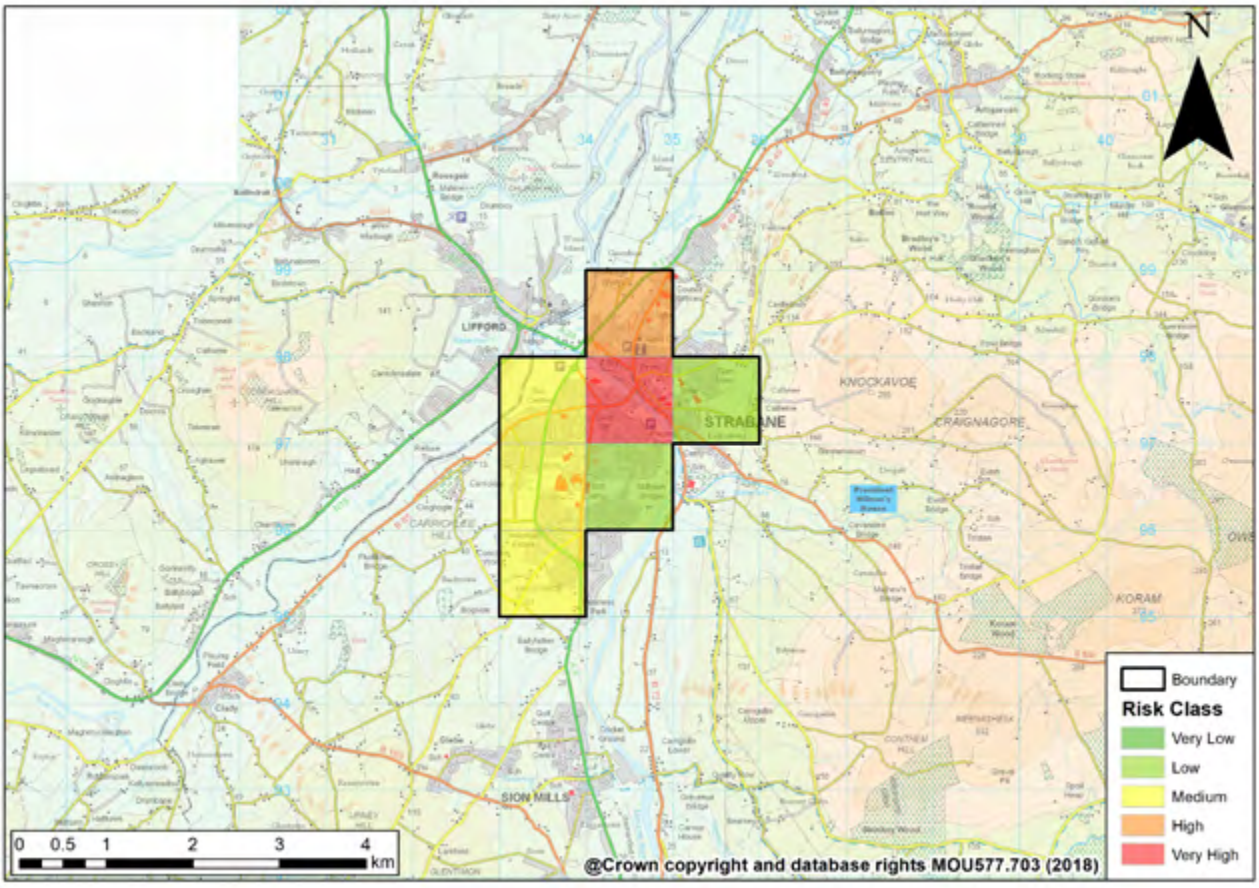
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Western	Strabane	7	TAPSFR

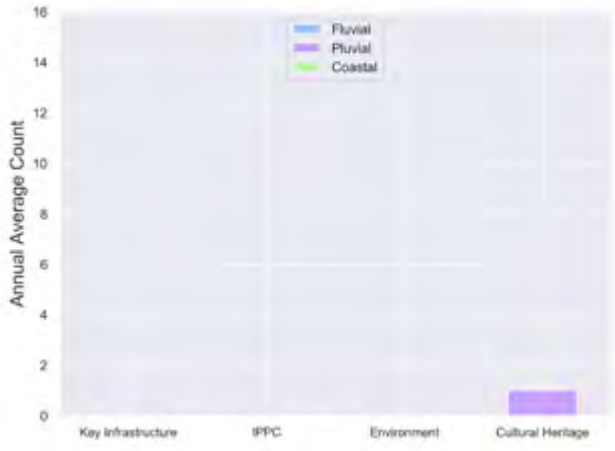
Summary

Strabane is situated in the North Western River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources. Strabane has significant defences to protect against flooding from fluvial sources.



Property at risk by source

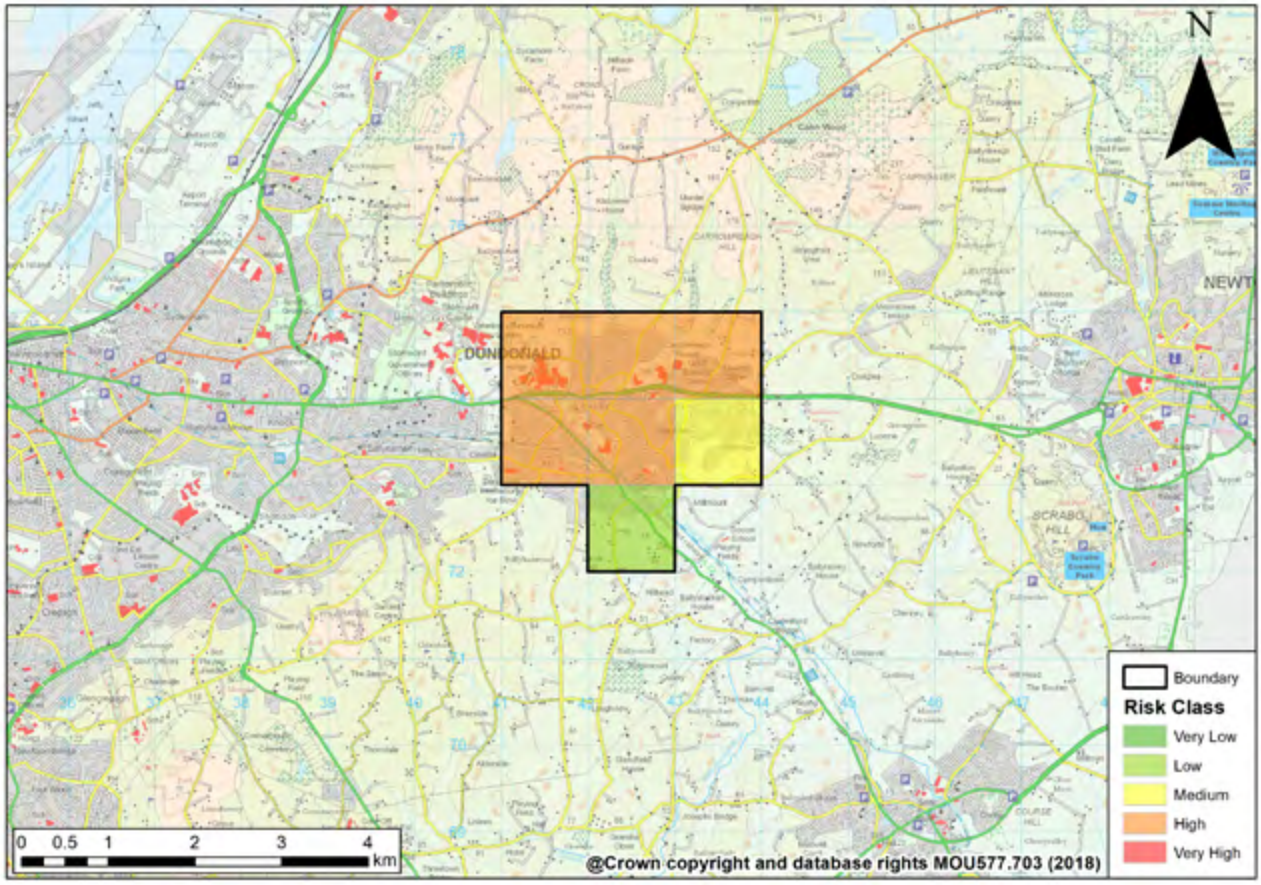
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Dundonald	7	TAPSFR

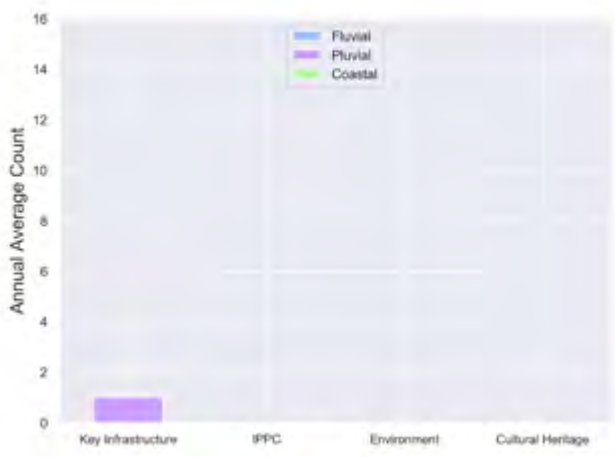
Summary

Dundonald is situated in the North Eastern River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources.



Property at risk by source

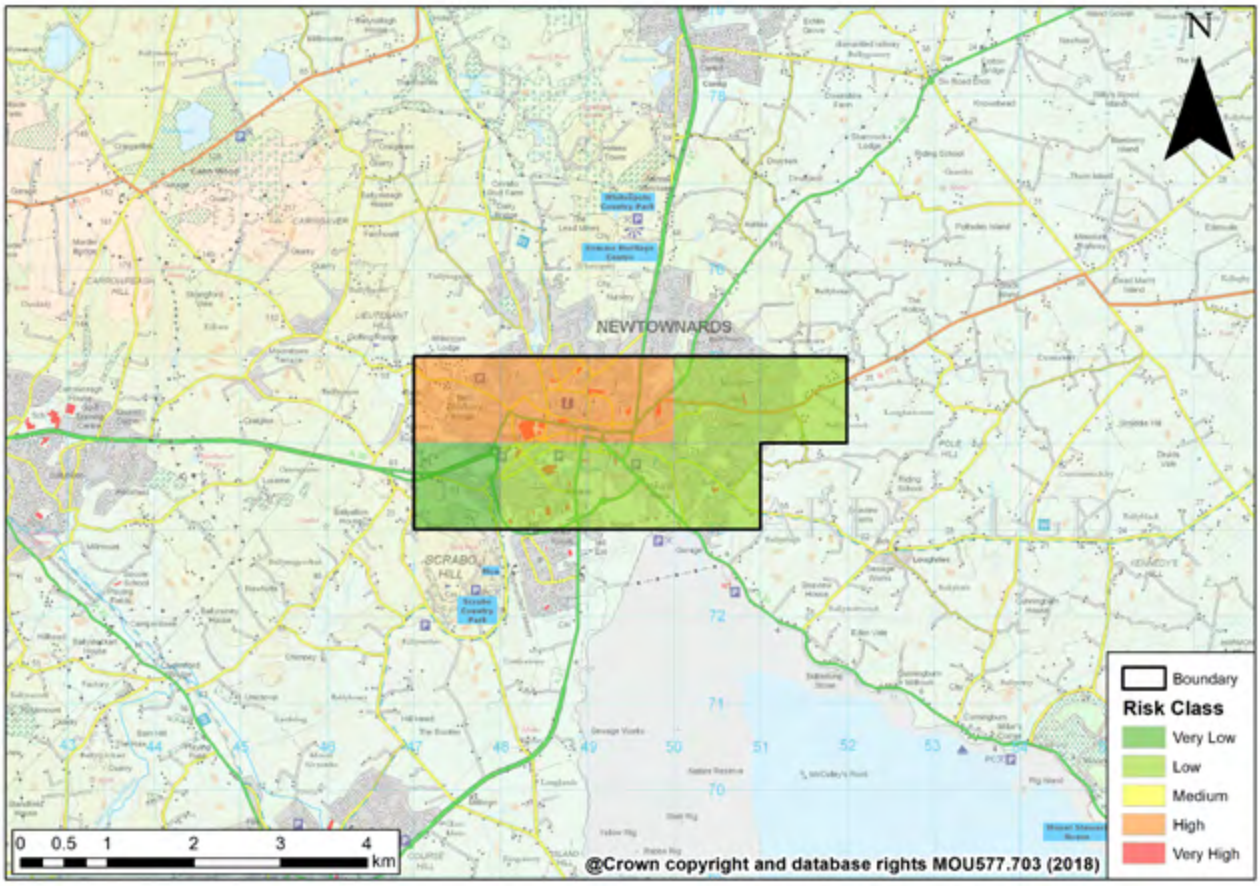
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Newtownards	9	TAPSFR

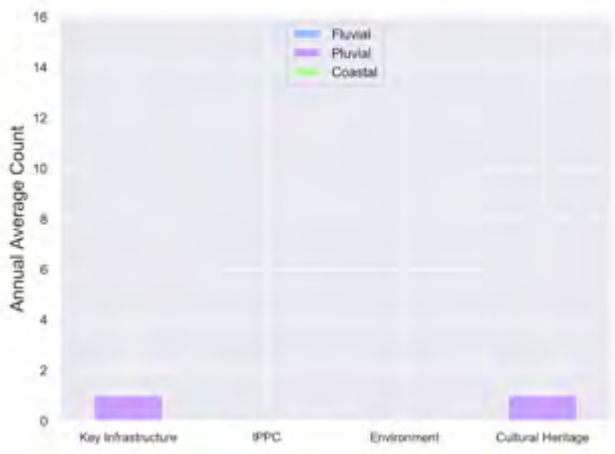
Summary

Newtownards is situated in the North Eastern River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. While it is a coastal town the main risk of flooding stems from fluvial and pluvial sources. Newtownards has significant defences extending southwards from the Portaferry Road to provide protection to the Newtownards area from the coastal source.



Property at risk by source

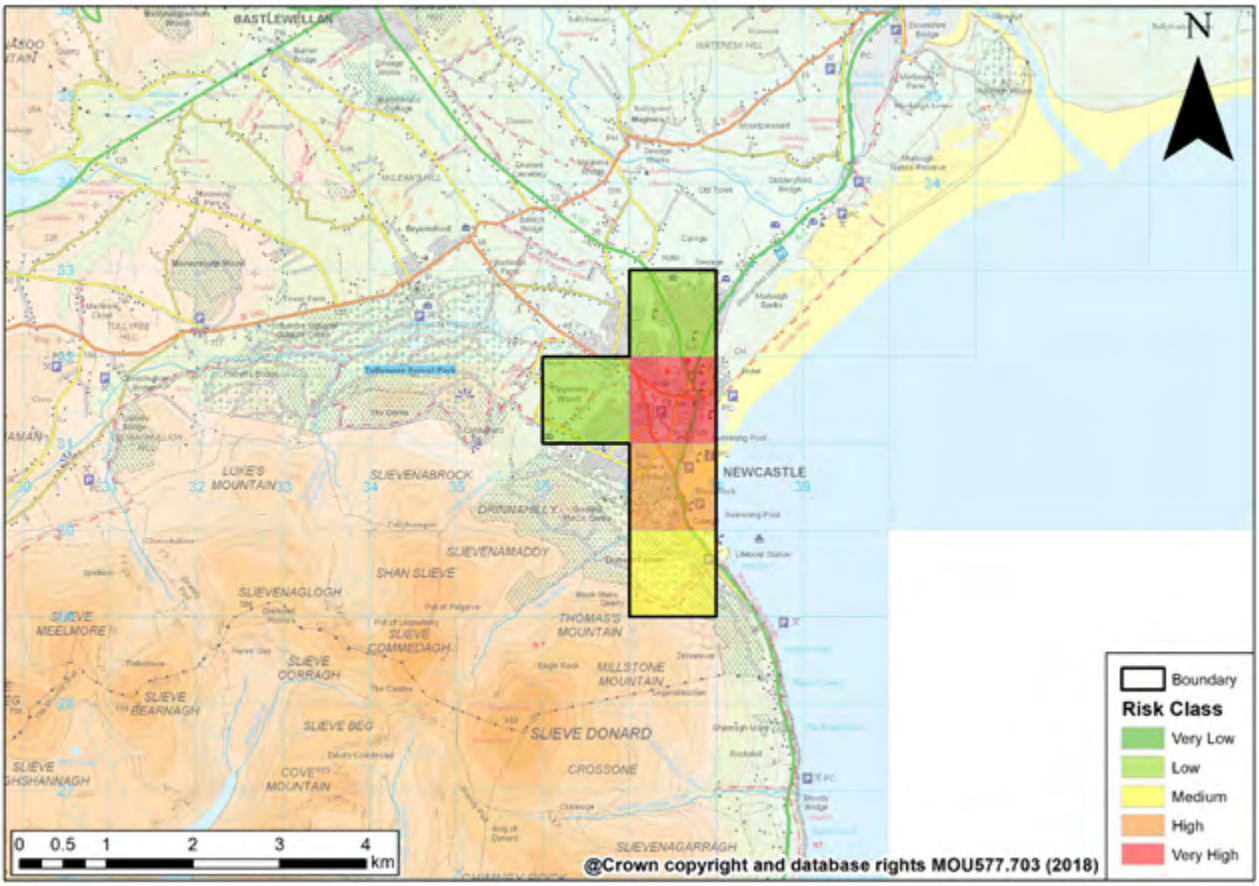
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Newcastle	5	TAPSFR

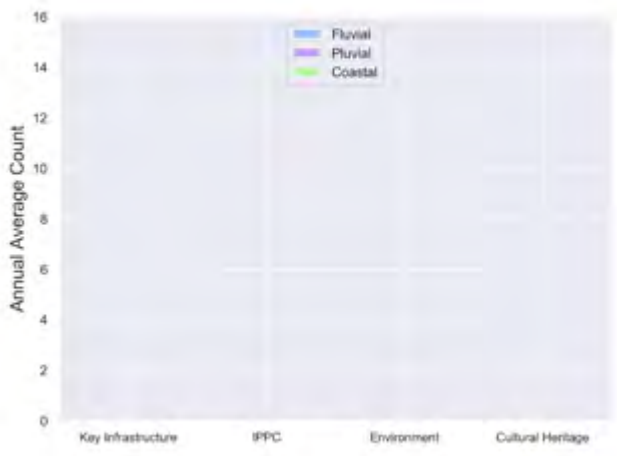
Summary

Newcastle is situated in the North Eastern River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. While it is a coastal town, the main risk of flooding stems from fluvial and pluvial sources. However, the tide could impact on the fluvial sources of flooding in extreme circumstances because of Newcastle's estuarine location where rivers join before entering the Irish Sea.



Property at risk by source

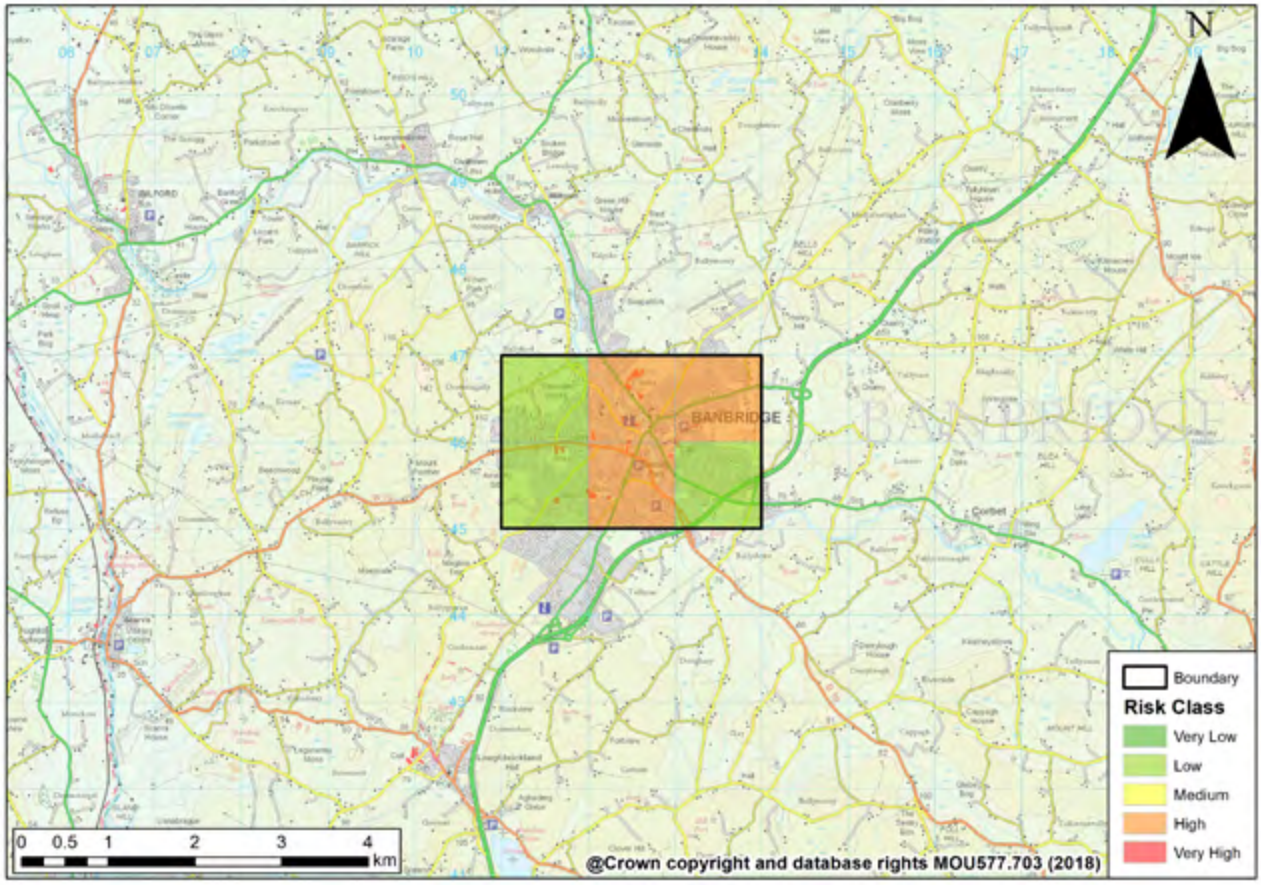
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Banbridge	6	TAPSFR

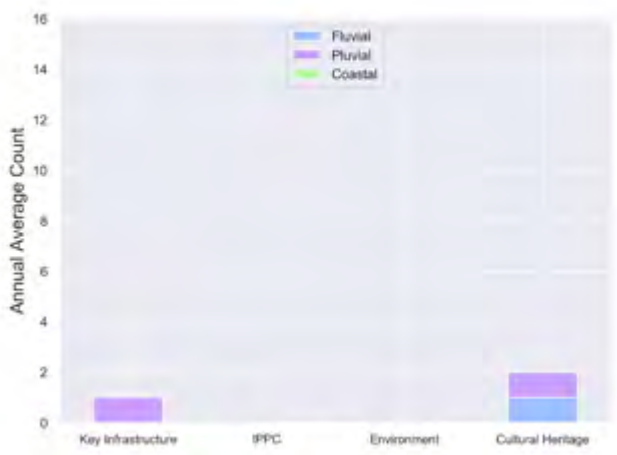
Summary

Banbridge is situated in the Neagh Bann River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources.



Property at risk by source

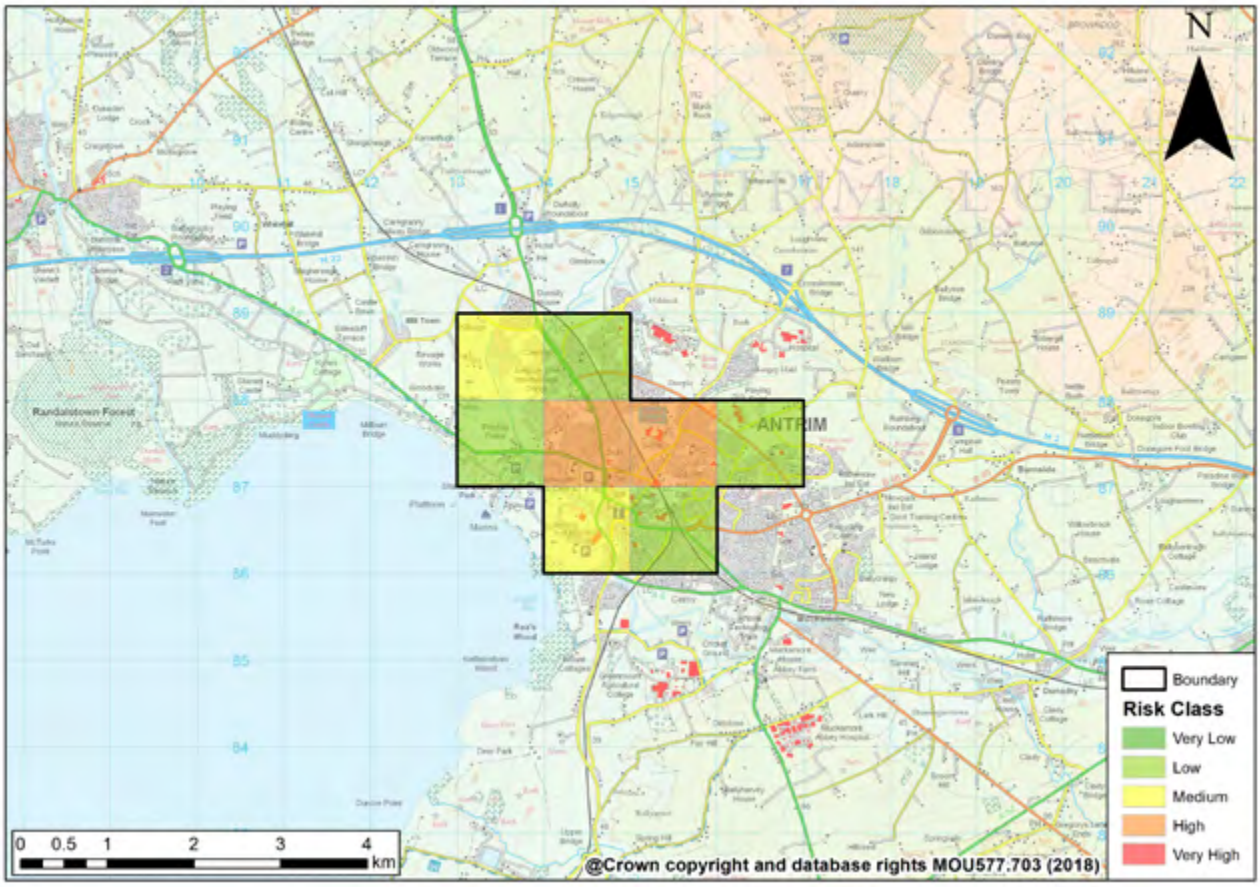
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Antrim	8	TAPSFR

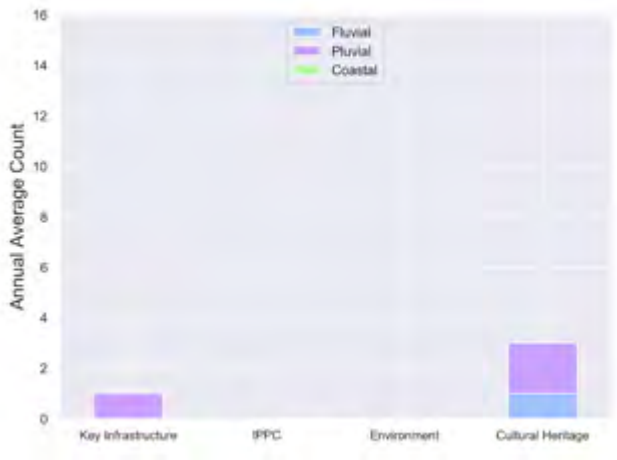
Summary

Antrim is situated in the Neagh Bann River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources.



Property at risk by source

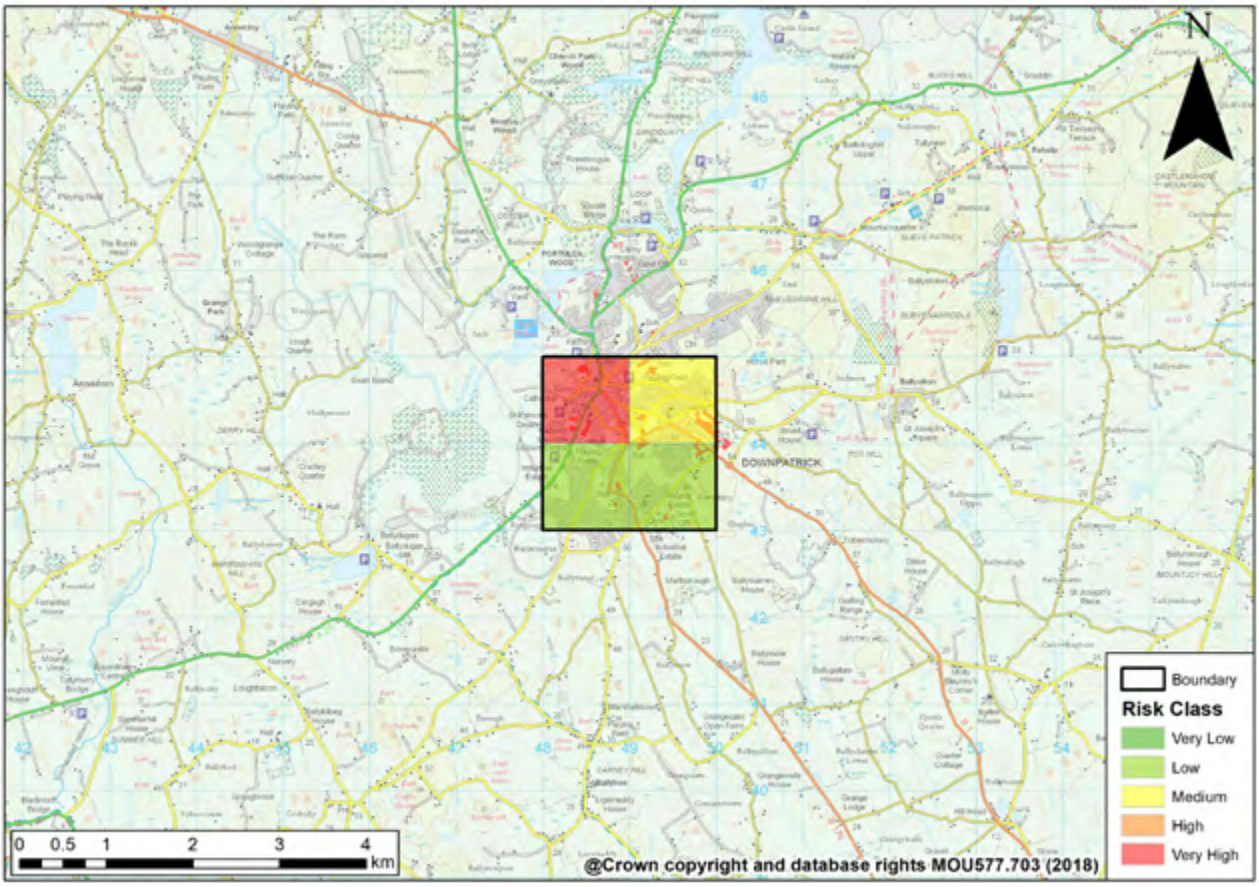
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
North Eastern	Downpatrick	4	TAPSFR

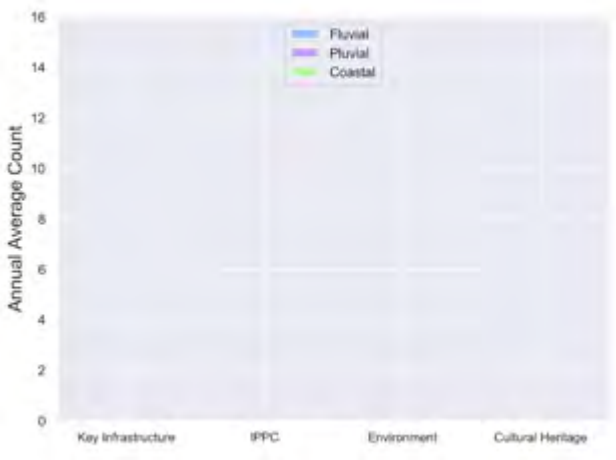
Summary

Downpatrick is situated in the North Eastern River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources. The coastal defence, the Quoile Barrier, provides protection to the Downpatrick area from the coastal source.



Property at risk by source

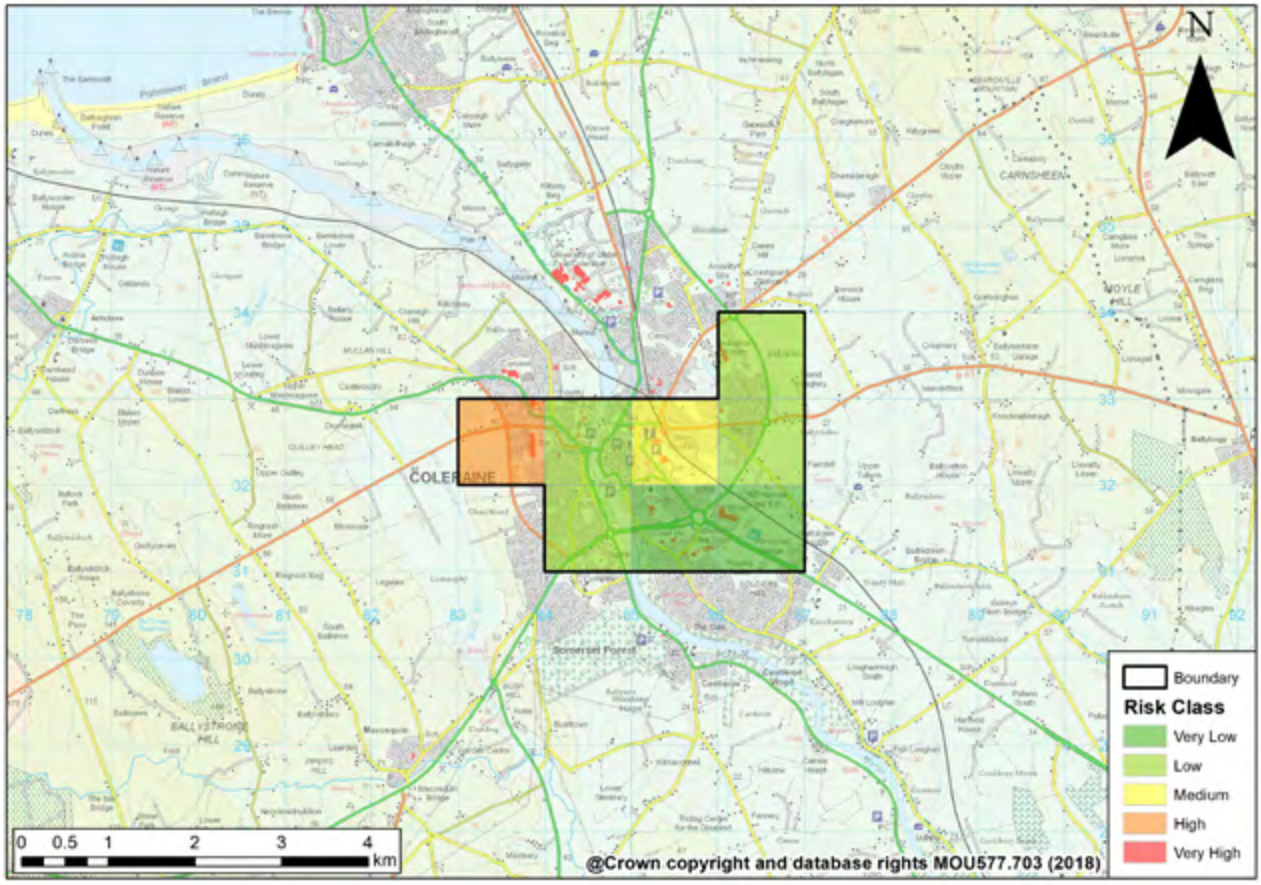
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Coleraine	8	TAPSFR

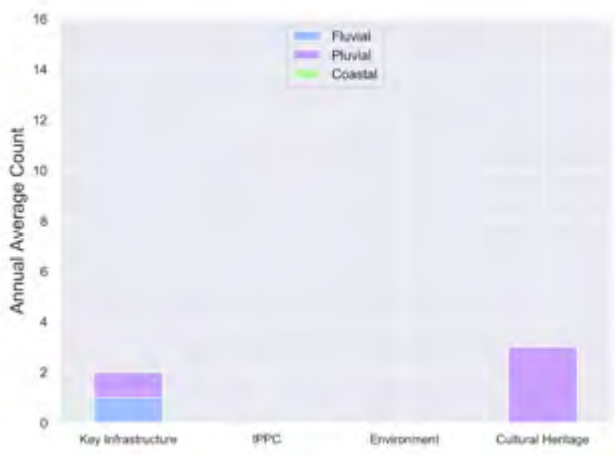
Summary

Coleraine is situated in the Neagh Bann River Basin District. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from fluvial and pluvial sources.



Property at risk by source

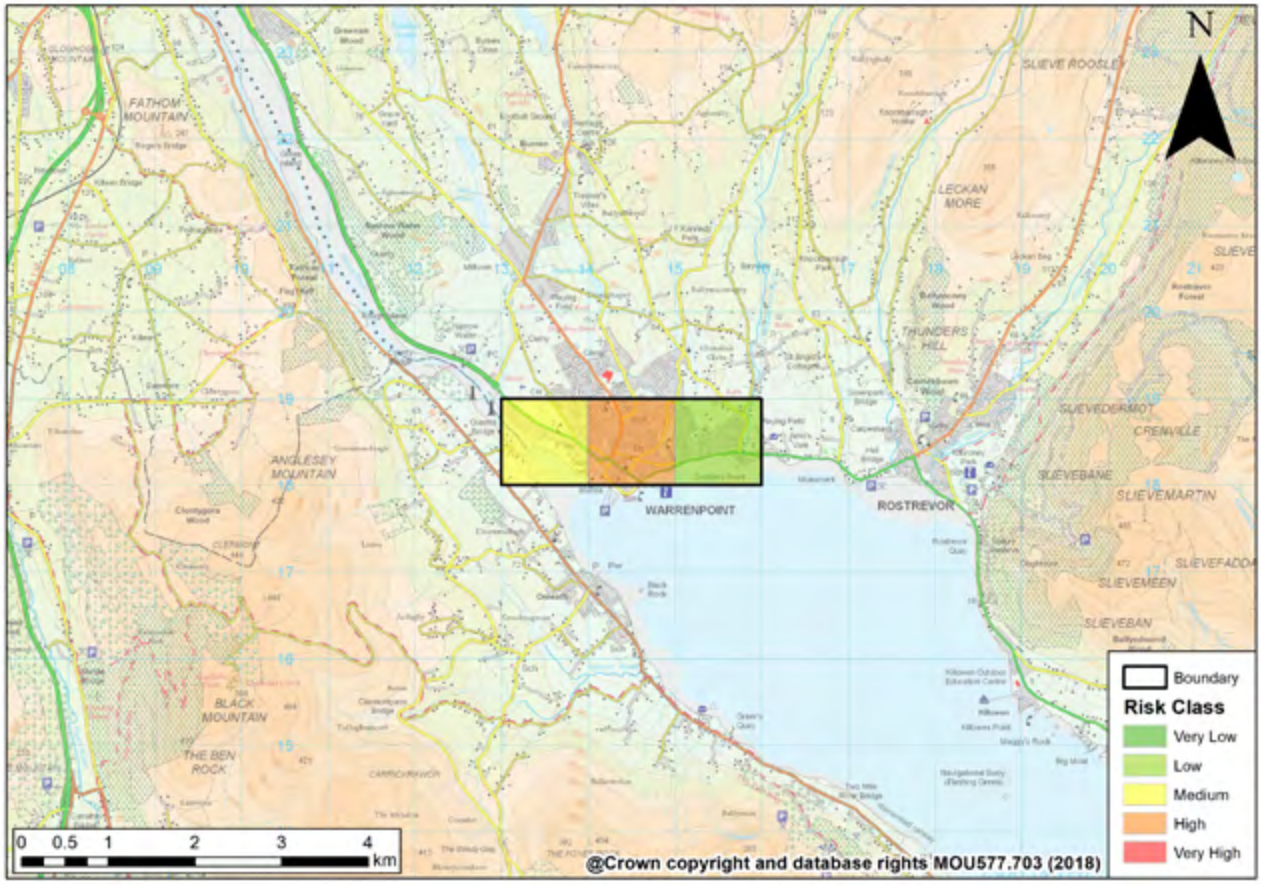
Other receptors at risk by source



RBD	Area Name	Area (km2)	Designation
Neagh Bann	Warrenpoint	3	TAPSFR

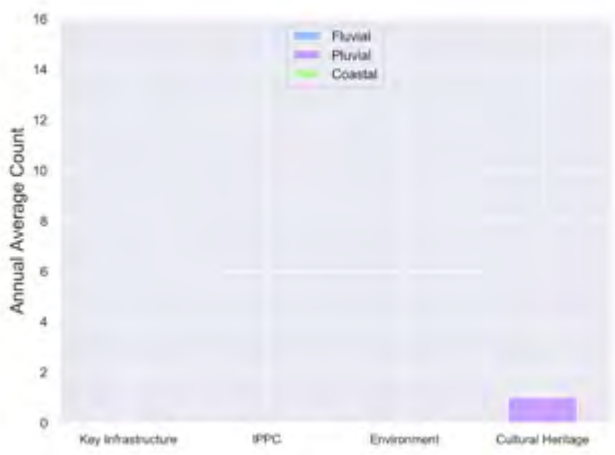
Summary

Warrenpoint is situated in the Neagh Bann River Basin District on the shoreline of Carlingford Lough. It was highlighed in the 2011 PFRA and has been designated a TAPSFR in the NIFRA 2018. Flood risk stems from pluvial, fluvial and coastal sources.



Property at risk by source

Other receptors at risk by source



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