Lurgan Feasibility Study

Lurgan Feasibility Report

IBE1298/June18

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Feasibility Report

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EXECUTIVE SUMMARY

DfI Rivers commissioned RPS Consulting Engineers to identify the flood risk associated with the complex watercourse system in and around Lurgan and assess options (including economic viability) for the alleviation of future flooding.

RPS liaised with DfI Rivers to request hydraulic models, flood reports, information on DfI Rivers' assets, historical flood information and any other available information relevant to the study area. A walkover survey of the study reaches was conducted by RPS alongside representatives from DfI Rivers in order to gain an appreciation of the topography of the catchment, flooding mechanisms and the identification of any key features such as structures along each of the watercourses within the study area. RPS updated the hydraulic model, with details provided in the Lurgan Modelling Report.

RPS then undertook a comprehensive option development and assessment process to ensure that all potential flood alleviation measures were considered. The works involved with each proposal were incorporated into revised models. This was to ensure that the preferred options would deliver the required reduction in flood risk to the relevant properties (to at least a 1% AEP event) and would not increase the risk of flooding elsewhere in the catchment. Three potential options were considered, Option 1 being the existing regime and therefore the baseline condition. The option appraisal showed that Options 2 and 3 would achieve the primary objective of providing the design Standard of Protection and that both would have similar impacts when considering the other objectives and constraints identified.

A detailed economic appraisal to evaluate the viability of each option was completed as part of the overall study. From this Option 2 was considered to be better value for money and is therefore the recommended preferred option, consisting of upstream storage, hard defences and sealing manholes.

The vision of DfI Rivers is to manage the flood risk to facilitate the social, economic and environmental development of Northern Ireland. To support this vision, the Agency aims to reduce the risk to life and the damage to property from flooding from rivers and the sea and to undertake watercourse and coastal flood management in a sustainable manner. RPS believes that the preferred option successfully achieves these aims of DfI Rivers.

1 INTRODUCTION

1.1 BACKGROUND

The Preliminary Flood Risk Assessment (Rivers Agency, December 2011) report identified Lurgan as an Area of Significant Flood Risk (APSR). There are several rivers which flow through Lurgan generally in a north westerly direction towards Lough Neagh (Figure 1.1). A number of areas within Lurgan have been historically affected by flooding, including Halfpenny, Clanrolla, Woodville, Silverwood Leaves and Knockramer Meadows. Park Lake to the east of Lurgan acts a reservoir and a number of watercourses through the town are heavily culverted.

Flooding in Lurgan is known to have occurred in August 2008, October 2011 and November 2014; affecting both residential and commercial properties, as well as local infrastructure.

In August 2008, widespread flooding took place throughout Northern Ireland and the Republic of Ireland. This was the result of exceptionally large amounts of rain fall over the course of a very short period of time. The majority of flooding occurred upstream of the Shane Park culvert and Flush River Diversion; where the channel is narrow and heavily vegetated.

A number of properties were affected on the Clanrolla Tributary, the Rivers Agency identified the culverted section of the watercourse to be undersized.

Flooding on the Halfpenny River at Knockramer Meadows was caused by a lack of capacity in the channel, its heavily vegetated nature and the restrictive culvert at the downstream end of the estate. In 2010, the River Agency replaced the existing accommodation bridge at this location with a 2.8m x 1.5m precast concrete box culvert.

Information relating to flood events which occurred in October 2011 and November 2014 is very sparse. Flooding which occurred in 2014 is said to have occurred along Mourne Road and Cottage Road.

Flooding is caused by sections of channel which have insufficient capacity and a number of undersized culverts which are unable to convey flood flows. Drainage issues and pluvial flooding may also exacerbate the flood risk within Lurgan.

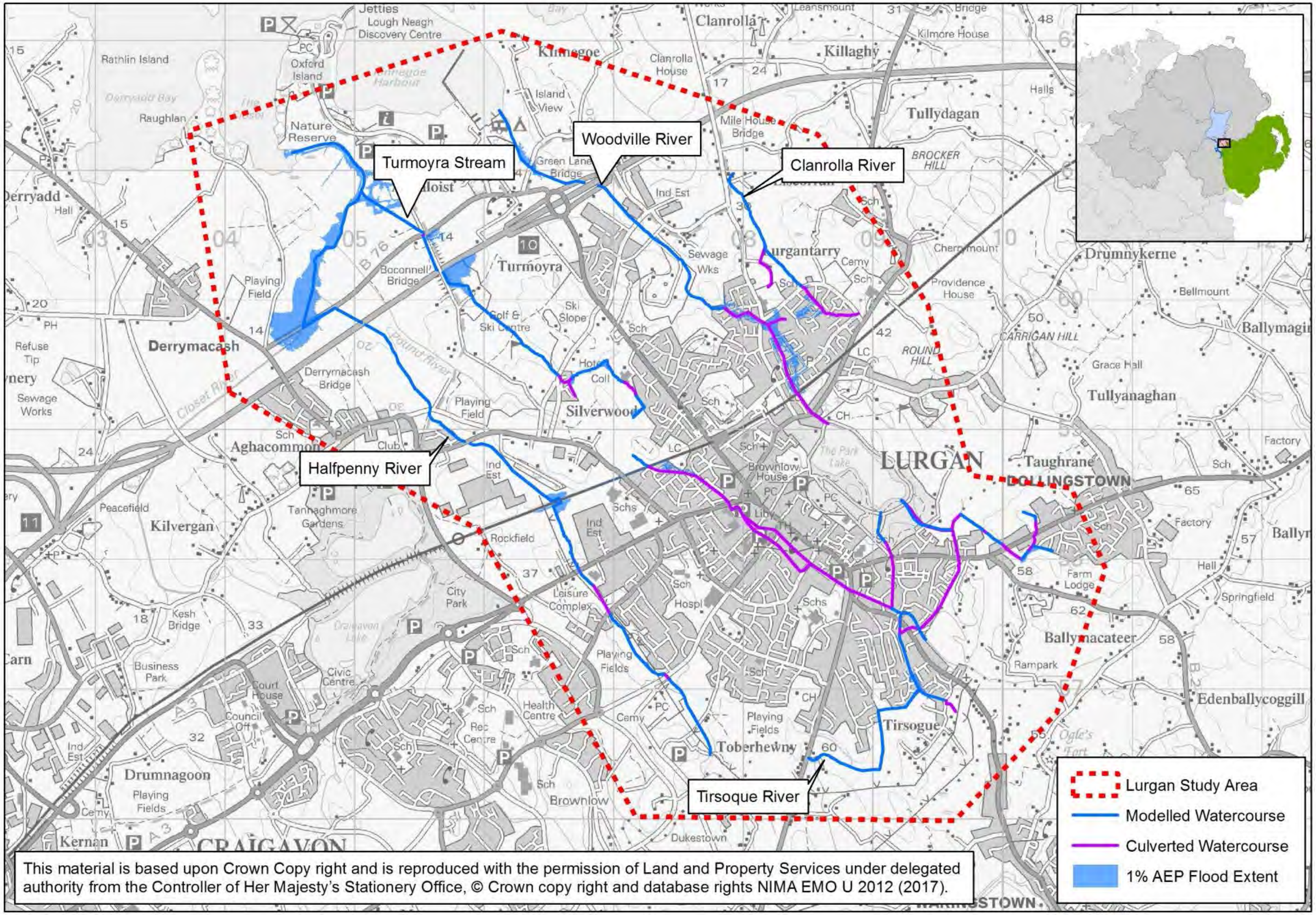

Figure 1.1 – Lurgan Study Area and General Location of Watercourses

1.2 AIMS AND SCOPE

DfI Rivers has appointed RPS to carry out a feasibility study for the complex watercourse system in and around Lurgan. The main aim of the study is to appraise flood risk and investigate options (including economic viability) which will alleviate flood risk in Lurgan.

The project brief included the following requirements:

- Investigate the effect any watercourse, located within the study area, may have on flood risk to the study area;
- Assess the flood risk to infrastructure and properties from flooding during a range of flood events;
- Identify the flood risk and quantify the flood damage avoidance benefit;
- Consider a wide range of flood alleviation options (including short term (0-5 years) interim measures and medium to long term measures (5+ years)) to alleviate potential future flooding and provide protection to properties currently at risk of flooding during events up to and including the 1 in 100 year return period flood (Q100) i.e. 1% Annual Exceedance Probability;
- Consider all aspects of suitable and sustainable options proposed, including but not limited to environmental, health and safety, technical, constructability, economic, sustainability etc.;
- Undertake an Economic Appraisal in accordance with 'The NI Guide to Expenditure Appraisal and Evaluation' (NIGEAE) and the 'Flood and Coastal Erosion Risk Management - Appraisal Guidance' (published by the Environment Agency);
- Outline recommendations and present the optimum solution.

2 FLOOD RISK ASSESSMENT

2.1 INTRODUCTION

DfI Rivers commissioned RPS to carry out a feasibility study for the complex watercourse system in and around Lurgan. The main aim of the study is to appraise flood risk and investigate options (including economic viability) which will alleviate flood risk in Lurgan.

A flood risk assessment was carried out for the Lurgan study in order to establish the risk to the various receptors located within the study area. The assessment considered the relevant economic, social and environmental receptors and their vulnerability to flooding. The overarching objective of the study is to provide protection within the study area to the 1% AEP standard of protection. However the FRA provided the information to define the specifics of this objective along with the constraints to be considered during the optioneering process.

This chapter details an overview of the flood hazard, identifying the flooding mechanisms along each of the watercourses. Details of the monetised and non-monetised risk are provided including the methods used and receptors considered. A summary of these findings are provided in this chapter and further details can be found in Appendix A and Appendix B.

2.2 OVERVIEW OF FLOOD HAZARD

Flooding occurs in five separate locations within Lurgan, these have been designated as flood cells (as shown in Figure 2.1) due to the location and flooding mechanism.

Flood Cell 1. Knocknashane
Flood Cell 2. Shankill
Flood Cell 3. Kiln Lodge
Flood Cell 4. North Circular Road
Flood Cell 5. Drumnamoe

Flooding within Knocknashane (flood cell 1) is due to insufficient capacity of the watercourse channel. Properties at risk during the 1% AEP are located at the confluence of two watercourses (known as LURG11 and LURG13 within the model), both contribute flow, raising water levels resulting in out of bank flooding. There are also two culverts in the area which have insufficient capacity to convey the 1% AEP flow, water levels are raised upstream of their inlets exacerbating the out of bank flooding.

Flooding within the Shankill (flood cell 2) area is due to surcharging manholes. The long culvert system which flows below Lurgan town becomes pressurised and flooding occurs from manholes creating overland flow paths which affect properties. This flood mechanism also occurs within the North Circular Road (flood cell 4) and Drumnamoe (flood cell 5) areas, both flood cells are located above long culvert systems which have insufficient capacity to convey the 1% AEP event flow, overland flow paths form as manholes surcharge.

Flooding at Kiln Lodge (flood cell 3) is due to insufficient culvert capacity, water levels are raised at the inlet to the culvert causing out of bank flooding.

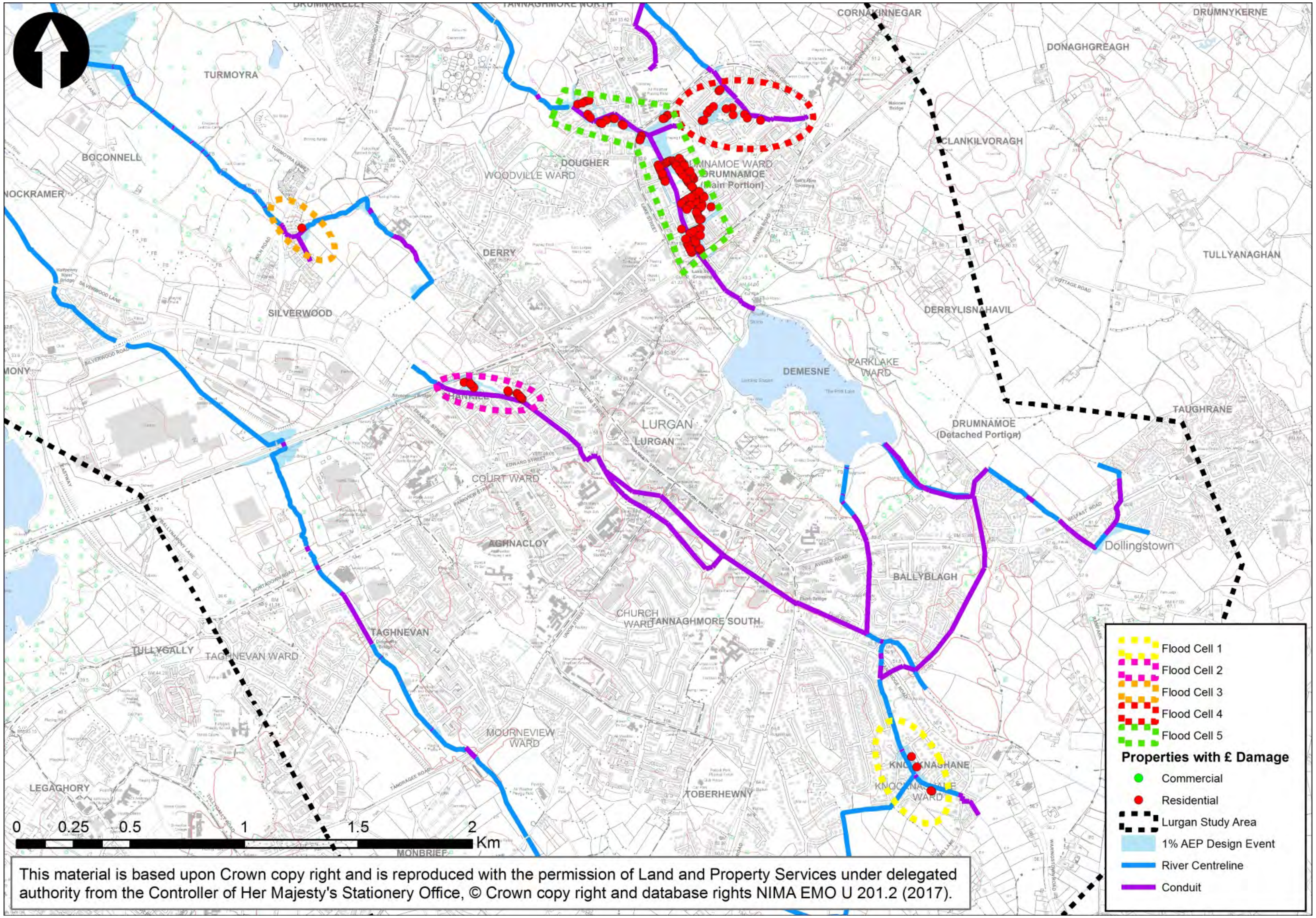

Figure 2.1 – Lurgan Flood Cells

2.3 FLOOD RISK RECEPTOR GROUPS

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 three receptor groups as described in Table 2.1 below. The level of flood risk to a receptor can be affected by its location within the flood extent, the depth with which it is flooded, the frequency which it is likely to be flooded and the receptors' vulnerability to flooding.

Table 2.1 - Flood Risk Receptor Groups

Flood Risk Receptor Group	Receptor	Indicator
Social and Cultural Heritage	NI Buildings, Community Receptors Areas of Special Archaeological Interest, Areas of Archaeological Potential, Historic Parks and Gardens, Listed Buildings, Industrial Heritage Buildings	Location, type and number Location, extent and nature
Environment	Salmonid Rivers, Ancient Woodland, RAMSAR, Special Area of Conservation (SAC), Special Protected Area (SPA), Area of Natural Beauty (AONB), Area of Special Scientific Interest (ASSI)	Location, type and number
Economic	Residential and Commercial Properties	Location, type, number, depth-damage data
	Electricity Substations, Gas Lines, Wastewater Treatment Works, Water Treatment Works	Location, type and number
	Road networks, Rail networks	Location, type and number

2.4 FLOOD RISK IN LURGAN

Table 2.2 below summarises the flood risk to the study area.

Table 2.2 - Flood Risk within Lurgan

Flood Risk Receptor Group	**Receptor**	**Risk**
Social and Cultural Heritage	NI Buildings, Community Receptors Areas of Special Archaeological Interest, Areas of Archaeological Potential, Historic Parks and Gardens, Listed Buildings, Industrial Heritage Buildings	No social buildings identified at risk One industrial heritage bridge at risk
Environment	Salmonid Rivers, Ancient Woodland, RAMSAR, Special Area of Conservation (SAC), Special Protected Area (SPA), Area of Natural Beauty (AONB), Area of Special Scientific Interest (ASSI)	Areas of Special Scientific Interest (ASSI's), Special Protected Area (SPA) and RAMSAR site at risk to the north of Lurgan in proximity to Lough Neagh. Small area of ancient woodland to north of Lurgan also at risk during a 1% AEP event (along the Woodville River near Woodville Elms).
Economic	Residential and Commercial Properties	168 residential properties are at risk from the 1% AEP flood event. The total AAD from residential properties is £50,095.78.
	Electricity Substations, Gas Lines, Wastewater Treatment Works, Water Treatment Works	Three small electricity hereditaments at risk during a 1% AEP flood event.
	Road networks, Rail networks	Roads at risk include the M1 motorway, Millennium Way and Francis Street, as well two C class roads and 47 unclassified roads.

2.5 MONESTISED RISK - 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

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.

2.5.1 Damage Assessment Guidelines

The damage assessment methodology follows the guidance in “Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal" (Penning-Rowsell, *et al*., 2013). This book is a successor to and replacement of the highly respected manual and handbook “The Benefits of Flood and Coastal Defence: A Manual of Assessment Techniques" (Flood Hazard Research Centre, Middlesex University, UK, 2005). This document was often referred to as the ‘Multi-Coloured Manual’ (MCM).

The new manual draws on collaboration between the Flood Hazard Research Centre, the Environment Agency, Defra and other stakeholders. Its use, accompanied by the MCM-Online, has been recommended for benefit assessment as part of a flood and coastal erosion risk management appraisal.

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 monetary 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.

The updated version of the manual provides a completely new set of data on the potential flood damage to non-residential properties, methods for assessing benefits in sectors not previously covered by MCM and, access to the rational and background on appraisal techniques, with links to the practical methods presented on a new web-based MCM.

For residential properties the new manual also incorporates the consideration of social grade and building periods. An example of the depth damage data for residential properties is shown in Figure 2.2 below.

3	Property-Type	MCM code	Property Type - Age	-0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8
4	Detached	111	pre-1919 Detached	1,606	1,606	15,018	26,224	43,860	54,476	64,439	71,559	78,045	85,808	94,353
5		112	1919-1944 Detached	1,009	1,009	7,046	11,355	19,934	24,468	29,727	32,245	36,222	40,039	44,545
6		113	1945-1964 Detached	884	884	8,637	13,957	23,791	28,777	34,509	37,624	41,590	45,092	49,433
7		114	1965-1974 Detached	754	754	7,117	11,402	19,934	24,427	29,758	32,315	36,033	39,049	42,763
8		115	1975-1985 Detached	792	792	7,879	12,541	21,976	27,465	33,745	37,601	41,446	44,805	48,761
9		117	utility Detached	641	641	2,485	3,606	5,154	6,410	7,305	8,599	10,442	12,473	14,903
10		118	post-1985 Detached	792	792	7,775	12,551	22,109	28,208	35,244	39,444	43,942	47,428	51,389
11	Semi-detached	121	pre-1919 Semi-Detached	1,481	1,481	6,028	9,251	15,891	19,548	24,299	26,388	29,460	32,176	35,335
12		122	1919-1944 Semi-Detached	1,507	1,507	6,735	10,613	17,474	21,123	25,875	27,950	30,873	33,292	36,273
13		123	1945-1964 Semi-Detached	1,507	1,507	6,679	10,552	17,409	21,055	25,802	27,875	30,797	33,211	36,189
14		124	1965-1974 Semi-Detached	661	661	5,381	8,745	15,229	18,690	23,313	25,222	28,329	30,994	34,375
15		125	1975-1985 Semi-Detached	629	629	5,110	8,393	14,985	18,734	23,642	25,973	28,750	30,916	33,610
16		127	utility Semi-Detached	643	643	2,434	3,583	5,092	6,385	7,330	8,530	10,030	11,727	13,648
17		128	post-1985 Semi-Detached	629	629	5,056	8,453	15,154	19,373	24,965	27,580	30,933	33,105	35,718
18	Terrace	131	pre-1919 Terrace	1,419	1,419	6,280	9,419	16,030	19,806	24,776	26,812	29,332	31,660	34,348
19		132	1919-1944 Terrace	1,468	1,468	7,043	11,261	19,328	22,966	27,797	29,843	32,646	34,805	37,541
20		133	1945-1964 Terrace	934	934	4,118	6,068	9,030	10,101	12,482	13,653	15,851	17,094	18,808
21		134	1965-1974 Terrace	723	723	5,925	9,636	16,504	20,089	24,778	26,833	29,843	32,149	35,060
22		135	1975-1985 Terrace	543	543	4,767	7,735	13,845	17,108	21,550	23,217	25,495	27,136	29,178
23		137	Utility Terrace	629	629	2,263	3,305	4,570	5,784	6,821	8,087	9,432	11,072	12,945
24		138	post-1985 Terrace	543	543	4,717	7,817	14,051	17,828	23,041	25,021	27,941	29,566	31,497
25	Bungalow	141	pre-1919 Bungalow	1,294	1,294	7,059	10,683	18,700	23,084	28,821	31,712	34,644	37,050	39,763
26		142	1919-1944 Bungalow	940	940	9,637	15,373	24,676	29,520	35,874	39,336	43,425	47,360	52,069
27		143	1945-1964 Bungalow	978	978	9,192	14,374	23,131	27,600	33,595	36,960	41,520	45,822	50,864
28		144	1965-1974 Bungalow	717	717	10,593	17,068	26,749	31,790	38,366	42,240	46,914	51,732	57,416
29		145	1975-1985 Bungalow	898	898	8,959	14,346	23,483	28,725	35,694	39,987	44,044	48,020	52,672
30		148	post 1985 Bungalow	898	898	8,844	14,538	24,117	30,630	39,452	44,548	50,161	54,181	58,656
31	Flat	151	pre-1919 Flat	1,294	1,294	5,517	8,512	14,203	17,084	21,490	22,940	24,871	26,231	27,914
32		152	1919-1944 Flat	765	765	8,362	13,632	22,101	26,319	31,905	34,431	37,142	39,560	42,437
33		153	1945-1964 Flat	765	765	4,935	7,668	13,807	16,816	21,006	22,633	24,783	26,140	27,873
34		154	1965-1974 Flat	543	543	7,232	11,859	19,519	23,411	28,735	30,987	33,642	35,849	38,565
35		155	1975-1985 Flat	543	543	5,468	8,891	15,674	19,303	24,514	26,769	28,973	30,534	32,481
36		157	utility Flat	616	616	2,058	2,987	3,967	5,038	6,096	7,369	8,553	10,145	11,971
37		158	post 1985 Flat	543	543	5,377	8,895	15,752	19,938	26,035	28,647	31,592	33,130	34,943

Figure 2.2 - MCM's Depth Damage Data for Residential Properties

2.5.2 Recording Damage Assessment Data

The damage assessment is carried out in order to quantify the economic risk to the study area. This requires many 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 2.3.

Two shapefiles created by RPS in order to complete the damage assessment are the buildings polygon shapefile and the Finished Floor Level (FFL) point shapefile.

The buildings polygon shapefile was created to contain background data for building polygons including building use and area.

The FFL shapefile includes data regarding the elevation mOD of doors/entries to properties within the study area. This FFL data was obtained from a threshold survey carried out.

An additional point shapefile was created to contain all information needed to complete the damage assessment. Information such as building area, FFL and water elevations from the modelled flood events (Q2, Q5, Q10, Q25, Q50, Q75 and Q100) were combined into this shapefile 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. This shapefile could then be used to show 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.

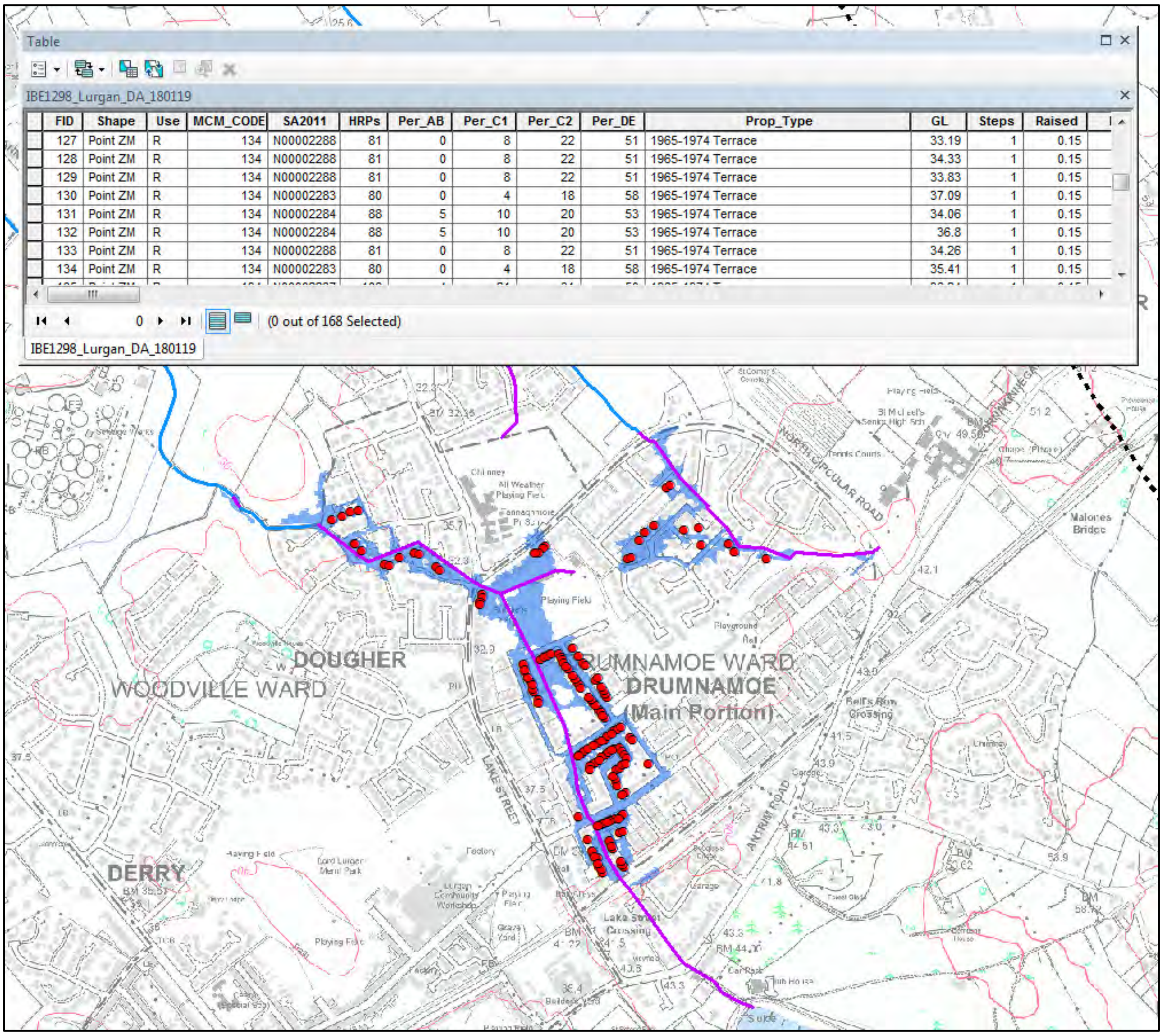

Figure 2.3 - Example shapefile with attributes showing damage assessment data

2.5.3 Categorisation of Properties

All properties within the 1% AEP floodplain were surveyed and classified according to MCM guidelines and included in the damage assessment. The type and age along with the social category of the occupants was noted. The MCM assigns a code to each property type to aid the damage calculations. Table 2.3 and Table 2.4 detail the various residential and non-residential property types.

Table 2.3 - Residential Properties MCM Codes

Property Type	MCM code	Property Type - Age
Detached	111	Pre-1919 Detached
	112	1919-1944 Detached
	113	1945-1964 Detached
	114	1965-1974 Detached
	115	1975-1985 Detached
	117	Utility Detached
	118	Post-1985 Detached
Semi-Detached	121	Pre-1919 Semi-Detached
	122	1919-1944 Semi-Detached
	123	1945-1964 Semi-Detached
	124	1965-1974 Semi-Detached
	125	1975-1985 Semi-Detached
	127	Utility Semi-Detached
	128	Post-1985 Semi-Detached
Terrace	131	Pre-1919 Terrace
	132	1919-1944 Terrace
	133	1945-1964 Terrace
	134	1965-1974 Terrace
	135	1975-1985 Terrace
	137	Utility Terrace
	138	Post-1985 Terrace
Bungalow	141	Pre-1919 Bungalow
	142	1919-1944 Bungalow
	143	1945-1964 Bungalow
	144	1965-1974 Bungalow
	145	1975-1985 Bungalow
	148	Post 1985 Bungalow
Flat	151	Pre-1919 Flat
	152	1919-1944 Flat
	153	1945-1964 Flat
	154	1965-1974 Flat
	155	1975-1985 Flat
	157	Utility Flat
	158	Post 1985 Flat

Table 2.4 - Non-Residential Property MCM Codes

<table>
<tr><th>New MCM Code</th><th>Property type</th><th>New MCM Code</th><th>Property type</th></tr>
<tr><td rowspan="23">2</td><td>Retail</td><td>N/A</td><td>Sport</td></tr>
<tr><td>Shop/Store</td><td>521</td><td>Sports Grounds and Playing Fields</td></tr>
<tr><td>(High Street) Shop</td><td>521</td><td>Golf Courses</td></tr>
<tr><td>Superstore/Hypermarket</td><td>523</td><td>Sports and Leisure centres</td></tr>
<tr><td>Retail Warehouse</td><td>523</td><td>Amusement Arcade/Park</td></tr>
<tr><td>Showroom</td><td>525</td><td>Football Ground and Stadia</td></tr>
<tr><td>Kiosk</td><td>526</td><td>Mooring/Wharf/Marina</td></tr>
<tr><td>Outdoor market</td><td>523</td><td>Swimming Pool</td></tr>
<tr><td>Indoor Market</td><td rowspan="12">6</td><td>Public Buildings</td></tr>
<tr><td>Vehicle Services</td><td>School/College/University/Nursery</td></tr>
<tr><td>Vehicle Repair Garage</td><td>Surgery/Health Centre</td></tr>
<tr><td>Petrol Filling Station</td><td>Residential Home</td></tr>
<tr><td>Car Showroom</td><td>Community Centres/Halls</td></tr>
<tr><td>Plant Hire</td><td>Library</td></tr>
<tr><td>Retail Services</td><td>Fire/Ambulance station</td></tr>
<tr><td>Hairdressing Salon</td><td>Police Station</td></tr>
<tr><td>Betting Shop</td><td>Hospital</td></tr>
<tr><td>Laundrette</td><td>Museum</td></tr>
<tr><td>Pub/Social club/wine bar</td><td>Law court</td></tr>
<tr><td>Restaurant</td><td>Church</td></tr>
<tr><td>Café/Food Court</td><td rowspan="6">8</td><td>Industry</td></tr>
<tr><td>Post Office</td><td>Workshop</td></tr>
<tr><td>Garden Centre</td><td>Factory/Works/Mill</td></tr>
<tr><td rowspan="4">3</td><td>Offices</td><td>Extractive/heavy Industry</td></tr>
<tr><td>Offices (non-specific)</td><td>Sewage treatment works</td></tr>
<tr><td>Computer Centres (Hi-Tech)</td><td>Laboratory</td></tr>
<tr><td>Bank</td><td>N/A</td><td>Miscellaneous</td></tr>
<tr><td rowspan="7">4</td><td>Warehouses</td><td>910</td><td>Car Park</td></tr>
<tr><td>Warehouse</td><td rowspan="3">Not currently available</td><td>Public Convenience</td></tr>
<tr><td>Electrical w/h</td><td>Cemetery/Crematorium</td></tr>
<tr><td>Ambient goods w/h</td><td>Bus Station</td></tr>
<tr><td>Frozen goods w/h</td><td>526</td><td>Dock Hereditament</td></tr>
<tr><td>Land Used for Storage</td><td>960</td><td>Electricity Hereditament</td></tr>
<tr><td>Road Haulage</td><td></td><td></td></tr>
<tr><td rowspan="8">51</td><td>Leisure</td><td></td><td></td></tr>
<tr><td>Hotel</td><td></td><td></td></tr>
<tr><td>Boarding House</td><td></td><td></td></tr>
<tr><td>Self-catering Unit</td><td></td><td></td></tr>
<tr><td>Hostel (including prisons)</td><td></td><td></td></tr>
<tr><td>Bingo hall</td><td></td><td></td></tr>
<tr><td>Theatre/Cinema</td><td></td><td></td></tr>
<tr><td>Beach Hut</td><td></td><td></td></tr>
</table>

For Lurgan, all properties found within the 1% AEP flood extent were categorised. This was carried out using data gained from site visits, surveys, OSi mapping and online mapping. The NI Buildings polygon layer was initially used to locate all the properties and provide their floor area. Sheds and garages, which have no depth damage data in the MCM guidelines, were removed and the remaining buildings categorised. Within the Lurgan 1% AEP flood extent there was a total of 271 properties (270 residential properties and 1 commercial property), however only 168 properties incur monetary damage (all residential).

Using the FCERM 2013 Manual, residential properties in the UK can be classified by house type, age and the social grade of the occupants. Taking into account these variables allows a more accurate estimation of inventory damages based on the presence or absence of household possessions. Table 2.5 below shows the social grade categories used in the FCERM 2013 Manual.

Table 2.5 - Approximated social grade categorisation by occupation

Social Grade	Description
AB	Upper middle and middle class: higher and intermediate managerial, administrative or professional.
C1	Lower middle class: supervisory or clerical and junior managerial administrative or professional.
C2	Skilled working class: skilled manual workers
DE	Working class and those at the lowest level of subsistence: semi-skilled and unskilled manual workers, unemployed and those with no other earnings (e.g. state pensioners).

Using Small Area Census data, the flood depth damage values for each property can be adjusted based on approximate proportions of households in each social group.

The following details were recorded within the buildings point shapefile attribute table:

Table 2.6 - Categorisation of Properties Data

Data Type	Attribute Name	Data Details
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
Small Area Code	SA2011	Code of Census data Small Area in which property is located
Floor Area	AREA	Floor area of the property

2.5.4 Property Threshold Level

The damage assigned to a property relates to the depth of water above floor level. As such the threshold level of all properties is required as part of the damage assessment. As a general rule 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. 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.

To achieve an accurate finished floor level for properties within the study area a threshold survey was conducted. However, as surveyors could not enter a property’s grounds, some of the data may not be representative and so it was necessary to check LiDAR defined ground levels and property entrance types in some regions.

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 = +150mm 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 = -150mm 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.

2.5.5 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 1 in 2, 1 in 5, 1 in 10, 1 in 25, 1 in 50, 1 in 75 and 1 in 100 year 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 2.5.4). The flood elevation was extracted by using the triangulated model output to find the maximum depth of water touching each building polygon. This process was achieved by carrying out a statistical analysis in ArcGIS and was carried out for each property and for each flood event. Table 2.7 below shows details which were recorded within the economic risk shapefile attribute tables:

Table 2.7 - Flood Depth of Properties Data

Data type	Attribute name	Data details
Flood level for all flood events	Q100_ELEV, Q75_ELEV, Q50_ELEV, Q25_ELEV, Q10_ELEV, Q5_ELEV, Q2_ELEV.	The maximum flood level adjacent to the building (mOD)
Flood depth for all flood events	Q100_Dp, Q75_Dp, Q50_Dp, Q25_Dp, Q10_Dp, Q5_Dp, Q2_Dp.	Difference between the flood level and FFL

2.5.6 Flood Damage to Properties

Once the depths of flooding are known the damage can be calculated using the MCM depth damage data. This is known as direct damage in that the flooding directly damages assets, it does not account for indirect damages such as heating costs to dry out the house. 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 2016 pound sterling prices and are based on the square metre of the floor area of the building. An example of this data is presented in Figure 2.2. A GIS tool has been developed which provides the direct damage in each flood event for each building in pound sterling 2016 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.

Table 2.8 - Flood Damage to Properties Data

Data type	Attribute name	Data details
Direct damage per meter square	Q100_M2Dm, Q75_M2Dm, Q50_M2Dm, Q25_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 2016 costs.
Principal Direct Damage (PDD) - Damage to property over full floor area	Q100_PDD, Q75_PDD, Q50_PDD, Q25_PDD, Q10_PDD, Q5_PDD, Q2_PDD.	Damage per meter square multiplied by floor area of building.

2.5.7 Utility and Emergency Costs

A cost will be associated with emergency services dealing with the flood events. Following the Environment Agency's Flood or Coastal Erosion Risk Management (FCERM) appraisal guidance, which the MCM guidance has been adapted to comply with, a value of 10.7% of the residential damages has been assigned to the emergency services costs. This figure is based on data collected from previous flood events in the UK and has also been used in this damage assessment.

An economic damage will be incurred in flood events relating to infrastructure utility assets. Examples of these may include electrical sub-stations and telecommunications assets. A utility damage of 20% of the principal direct damage has been applied to account for these impacts, which have been set based on the analysis of damages from historical flooding in the UK.

A cost will be associated with emergency services dealing with the flood events. Following the MCM guidance and the value adopted for the CFRAM Studies, the emergency costs have been set at 8.1% of the principal direct damages for this assessment.

The details in Table 2.9 were recorded within the economic risk shapefile attribute tables:

Table 2.9 - Emergency Cost Data

Data type	Attribute name	Data details
Utility costs	Q100_Util, Q75_Util, Q50_Util, Q25_Util, Q10_Util, Q5_Util, Q2_Util.	Equal to 20% of the PDD.
Emergency costs	Q100_Emerg, Q75_Emerg, Q50_Emerg, Q25_Emerg, Q10_Emerg, Q5_Emerg, Q2_Emerg.	Equal to 8.1% of the PDD.
Event Damage	Q100_EvDam, Q75_EvDam, Q50_EvDam, Q25_EvDam, Q10_EvDam, Q5_EvDam, Q2_EvDam.	Summed direct damage of any one event. This is the total of the PDD, utility damage and emergency costs.

2.5.8 Intangible Impacts of Flooding

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 stress, health effects and loss of memorabilia, which can be as important as direct material damage to householders. The latest MCM guidance assesses these impacts as intangible benefits that are associated with flood defence improvements. The MCM refers to a table produced by Defra for intangible benefits afforded by flood alleviation works, available in the Flood and Coastal Defence Project Appraisal Guidance as provided in Table 2.10; this table was used in the assessment. The calculated intangible benefits were summed with the benefits afforded relating to direct damages to provide the total benefit; this is discussed in more detail in later sections. In line with the methodology, the intangible benefit is not capped.

Table 2.10 - Intangible Benefits Associated with Flood Risk Management Improvements (2016/17 prices), originally produced by Defra, 2004

Standard of Protection After – AFP (RP in years)										
Standard of protection before – AFP (RP in years)			**0.007**	**0.008**	**0.01**	**0.013**	**0.02**	**0.033**	**0.05**	**0.1**
			-150	**-125**	**-100**	**-75**	**-50**	**-30**	**-20**	**-10**
	1	**-1**	£284	£280	£260	£199	£95	£33	£15	£6
	0.1	**-10**	£279	£274	£254	£193	£88	£28	£10	£0
	0.05	**-20**	£267	£262	£245	£183	£78	£17	£0	-
	0.033	**-30**	£251	£246	£227	£166	£61	£0	-	-
	0.02	**-50**	£189	£184	£165	£105	£0	-	-	-
	0.013	**-75**	£85	£81	£61	£0	-	-	-	-
	0.01	**-100**	£24	£19	£0	-	-	-	-	-
	0.008	**-125**	£5	£0	-	-	-	-	-	-

No intangible damages are assigned to commercial properties as these costs do not apply at the same level.

2.5.9 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 100 years and discounted back to present day costs; this is known as present value damage (pvD). The events that were considered for this study were the 1 in 2, 1 in 5, 1 in 10, 1 in 25, 1 in 50, 1 in 75 and 1 in 100 year flood events.

The AAD can best be described by considering the graph shown Figure 2.4. 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 1 in 2, 1 in 5, 1 in 10, 1 in 25, 1 in 50, 1 in 75 and 1 in 100 year flood events.

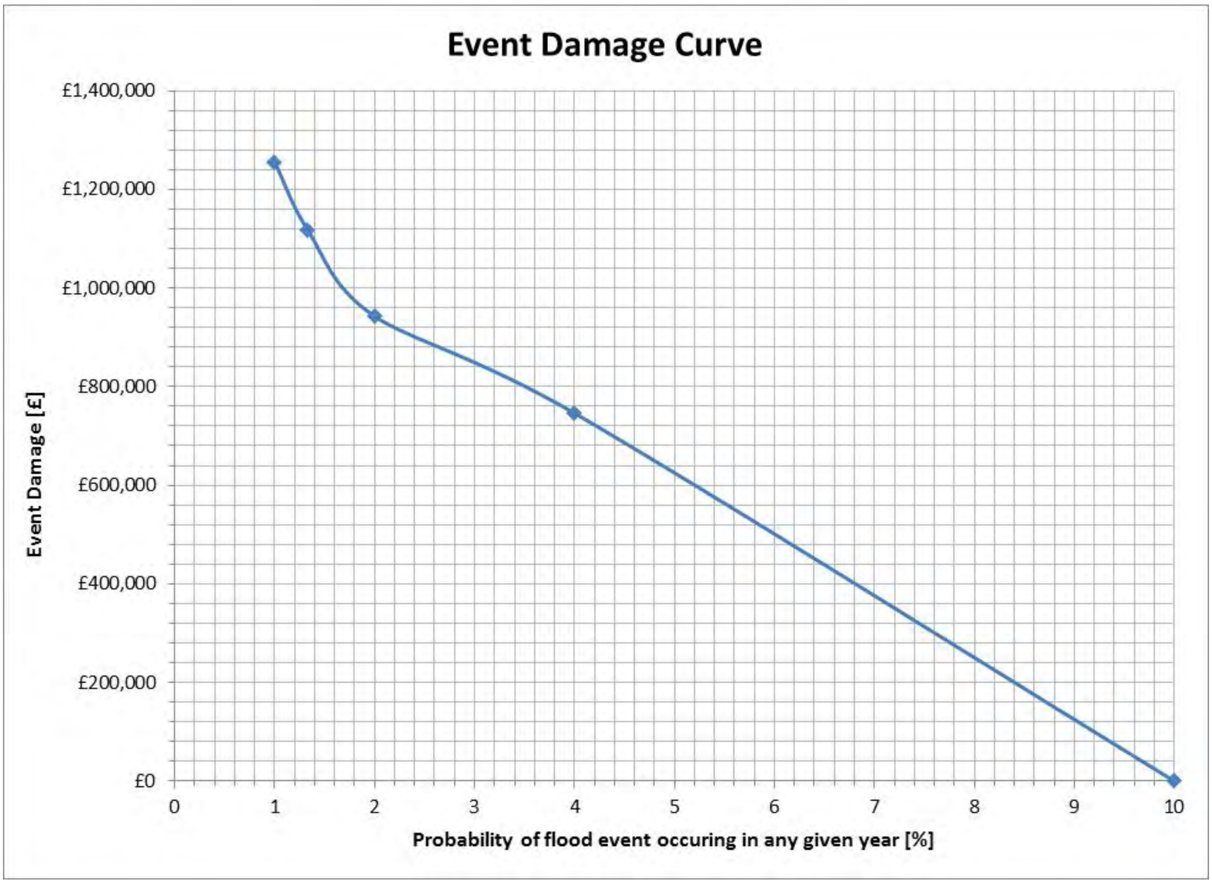

Figure 2.4 – Lurgan Event Damage Curve

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 100 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. For this project the discount rates were taken from the Treasury's 'Green Book' (HM Treasury, 2003), as shown in Table 2.11 below.

Table 2.11 - The Green Book's Long Term Discount Rate

Period of Years	**0 - 30**	**31 - 75**	**76 - 125**
Discount Rate	3.5%	3.0%	2.5%

This amounted to factoring the AAD by 29.813. The AAD and PvD are calculated for the direct damages and intangible damages separately then totalled to give the overall damage available.

The following details were recorded within the economic risk shapefile attribute tables:

Table 2.12 - AAD and pvD Data

Data type	**Attribute name**	**Data details**
Annual Average Damage for direct damages, intangible damages	AAD	The equation to calculate the AAD is as follows: (((([Q2_EvDam]+[Q5_EvDam])/2*(0.5-0.2)+([Q5_EvDam]+[Q10_EvDam])/2*(0.2-0.1)+([Q10_EvDam]+[Q25_EvDam])/2*(0.1-0.04)+([Q25_EvDam]+[Q50_EvDam])/2*(0.04-0.02)+([Q50_EvDam]+[Q75_EvDam])/2*(0.02-0.01333)+([Q75_EvDam]+[Q100_EvDam])/2*(0.01333-0.01))
Present value damage	PvD	The AAD factored by 29.813.

2.5.10 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 a combination of both factors. Where such a situation occurs it is necessary to cap the damages at the market value.

When capping damages for a property, the regional average risk free market value is used. Detailed research was carried out in order to establish an accurate and robust representation of property values. For residential properties in Lurgan the 2017 Quarter 3 Standardised House Price for Armagh City, Banbridge & Craigavon was used. This information was produced by Land and Property Services and released under the Open Government License v3.0.

For a non-residential property its rateable value multiplied by a factor which reflects the added value of percentage rental yield from that property is used. Research was carried out to identify both the rateable value and the average rental yield for commercial properties in the region. Again detailed research was undertaken to identify robust rateable values for commercial properties in the region. Data produced by the Department of Finance detailing the prime rate per square metre for shops, offices, warehouses and factories in December 2017 was obtained. Relevant wards and therefore properties could be identified within the document. An average rate (£/m^2) for each property type across the relevant wards was calculated and used for the assessment.

For percentage rental yield, an average for Northern Ireland of around 6.9% was identified using data produced by Savills, 2017, therefore using MCM guidance a multiplier of 16.7 would be appropriate.

The methods used to acquire robust values for capping damages were recommended in the FCERM Manual 2013 and the MCM 2016.

The approach taken in this study is to cap the direct damages then add the intangible benefit to provide the total available benefit. In line with MCM guidance the intangible benefit is not capped.

The following details in Table 2.13 were incorporated within the economic risk shapefile attribute tables:

Table 2.13 – Lurgan Capping Damages Data

Data type	**Attribute name**	**Data details**
Capping value for direct damages	PvD_Cap, PvDInt_Cap,	Residential property damages over £117,637 are capped at this value. Commercial property damages capping value = rateable value per square metre x floor area x 16.7
Present value damage in baseline scenario (capped)	PvD_BLcap	Any present value damage greater than the CapVal in the baseline scenario was capped at the CapVal. Any damage less than the CapVal was let equal the original present value damage.

Table 2.14 – Lurgan Commercial Capping Damages Data

MCM_Code	**Property Type**	**Capping Value /m^2**
2	Shops	£149.32 x 16.7 = 1623.41
3 **51** **6**	Offices Leisure Public Buildings	£60.04 x 16.7 = 953.07
4 **8** **910** **960**	Warehouses Industry Car Park Electricity Hereditament	£26.22 x 16.7 = 447.06

2.5.11 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.

2.5.12 Benefits

The total economic benefit for the study area was calculated as the sum of the direct and intangible benefits. The direct benefit was calculated to be the same as the capped damages in the present day scenario; with damages being assessed up to the 1% AEP, protecting all properties in the assessment to the 1% AEP results in there being no residual damage within the study area. The intangible benefit is uncapped, as previously discussed. The relevant fields in the economic risk shapefile are provided in Table 2.15.

Table 2.15 - Benefit and Related Fields

Data type	**Attribute name**	**Data details**
Annual average benefit (AAB) relating to intangible damages avoided	AAB_Int	Annual average benefit (AAB) relating to intangible damages avoided.
Present value benefit (PvB) relating to intangible damages avoided	PvB_Int	The AAB factored by 29.813. Note that unlike the direct damages this has not been capped.
Final present value benefit for the study area	PvB_Final	Calculated by the following: PvB_Cap + PvB_Int

2.5.13 Summary of Damage Assessment

The field 'PvB_Final' in the attribute table of the economic benefit shapefile is the total potential avoided damage which sums the capped present value direct damages and the uncapped present value intangible benefit. This gives the overall present value benefit. The table below summarises the damages associated with Lurgan.

Direct PvD (uncapped)	**Direct PvD (capped)**	**Intangible PvB**	**Total PvB**
£1,493,505.47	£1,493,505.47	£1,094,196.52	£2,587,701.99

2.6 NON-MONETISED RISK

2.6.1 Economic Receptors

Economic receptors which were considered within this study include Residential and Commercial Properties, Wastewater Treatment Works and Water Treatment Works, Electricity Substations, Gas Lines, Roads and Railways. Figure 2.5 gives an example of the economic risk maps created for Lurgan and highlights some of the receptors which were located within the Lurgan Study Area. All other economic risk maps may be found in Appendix B.

During the design flood event 168 residential properties were identified as at risk of incurring monetary damage during a 1% AEP flood event. No commercial properties were identified at risk. In addition to the residential properties, approximately 640m of the railway line and roads such as the M1 Motorway, Millennium Way, Francis Street and a number of other unclassified roads have also been identified as at risk of flooding.

Three small electricity hereditaments were also identified as at risk during the design flood event. Other receptors such as Wastewater Treatment Works and Water Treatment Works were not identified as at risk of inundation.

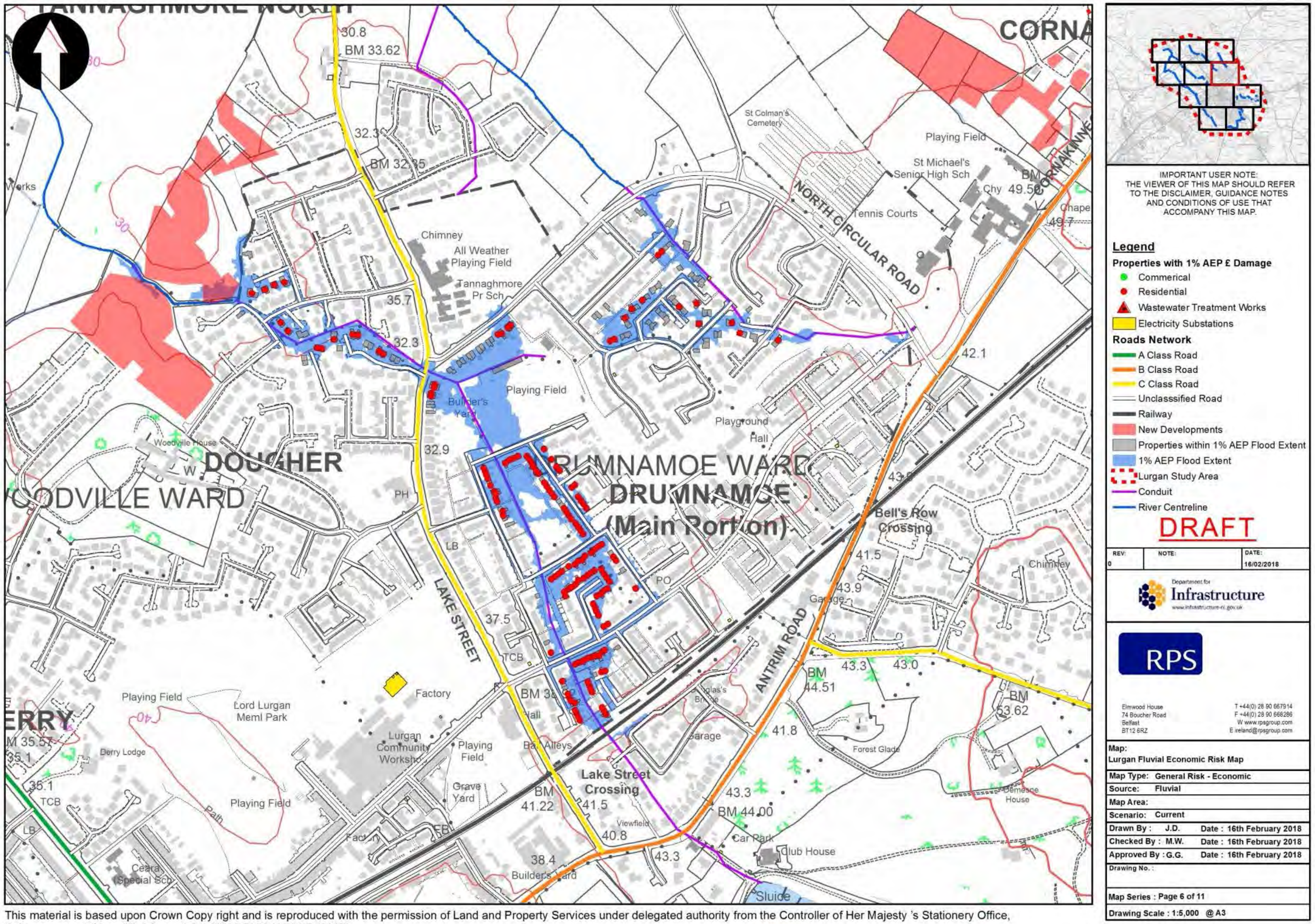

Figure 2.5 – Summary of Flood Risk to Economic Receptors in the Lurgan Study Area

2.6.2 Social Receptors

Social receptors considered within this study include Industrial Heritage Buildings, Listed Buildings, Historic Parks and Gardens, Areas of Archaeological Potential, Areas of Archaeological Interest, Community Receptors and Residential and Commercial Properties. Figure 2.6 gives an example of the social risk maps created for Lurgan and highlights receptors which were located within the Lurgan Study Area. All other social risk maps may be found in Appendix B.

A bridge within the flood extent was identified as an industrial heritage structure. While the bridges are considered flood resilient and would not require protection, the status of the structures should be considered during optioneering to avoid alteration or damage if possible.

The Brownlow House site at Lurgan Park is classified under historic parks and gardens. This should be considered if there is any possibility that the water levels within Park Lake should increase above ‘normal’ operating levels, which could bring about flooding in this area. Water levels in Park Lake are currently controlled by a siphon structure at its outlet (located at the northern boundary of the lake). The siphon structure is discussed within the Lurgan Feasibility Study, Modelling Report (IBE1298/February/2018).

Other receptors such as the police station, fire station, schools and residential/nursing homes are not at direct risk of flooding but should be considered during the optioneering phase to ensure access is maintained.

2.6.3 Environmental Receptors

Environmental Receptors which were considered within this study include Salmonid Rivers, Ancient Woodland, Areas of Specific Scientific Interest (ASSI), Areas of Natural Beauty (AONB), Special Areas of Conservation (SAC), Special Protection Areas (SPA) and RAMSAR. Figure 2.7 gives an example of the environmental risk maps created for Lurgan and highlights some receptors which were located within the Lurgan Study Area. All other environmental risk maps may be found in Appendix B.

An Area of Specific Scientific Interest (Lough Neagh) and a Special Protected Area (Lough Neagh and Lough Beg) is located to the north of the study area. Modelled sections of the Halfpenny, Turmoyra and Woodville Rivers are situated within this designation. A RAMSAR designation (Lough Neagh and Lough Beg site) also extends into the same three watercourses as far as the M1 Motorway. Areas of Ancient Woodland were identified in the Lurgan study area, most notably surrounding the Lake at Lurgan Park and downstream along the Woodville River in the Woodville Gate and Woodville area. Consideration should be given to these areas during the optioneering process.

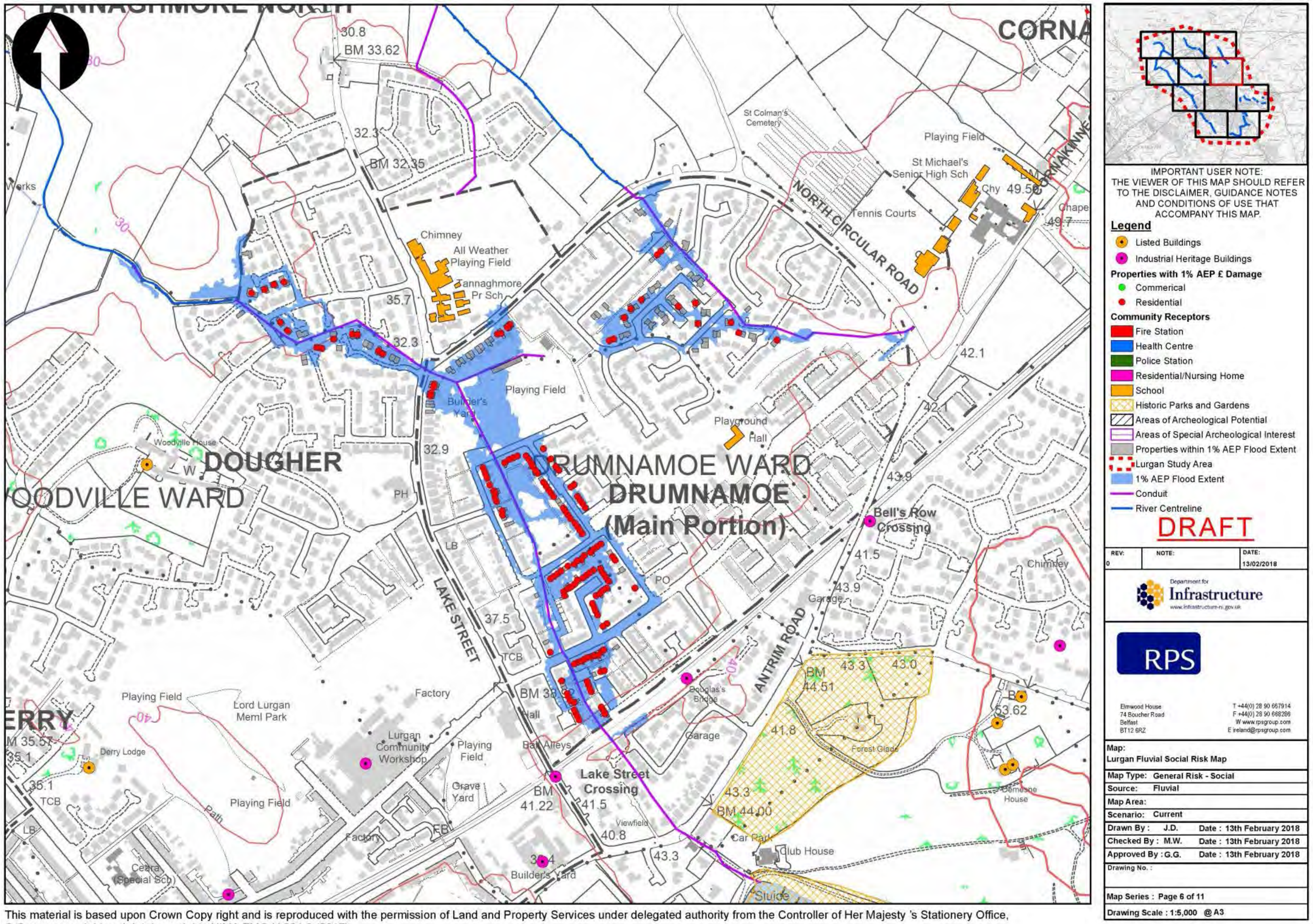

Figure 2.6 - Summary of Flood Risk to Social Receptors in the Lurgan Study Area

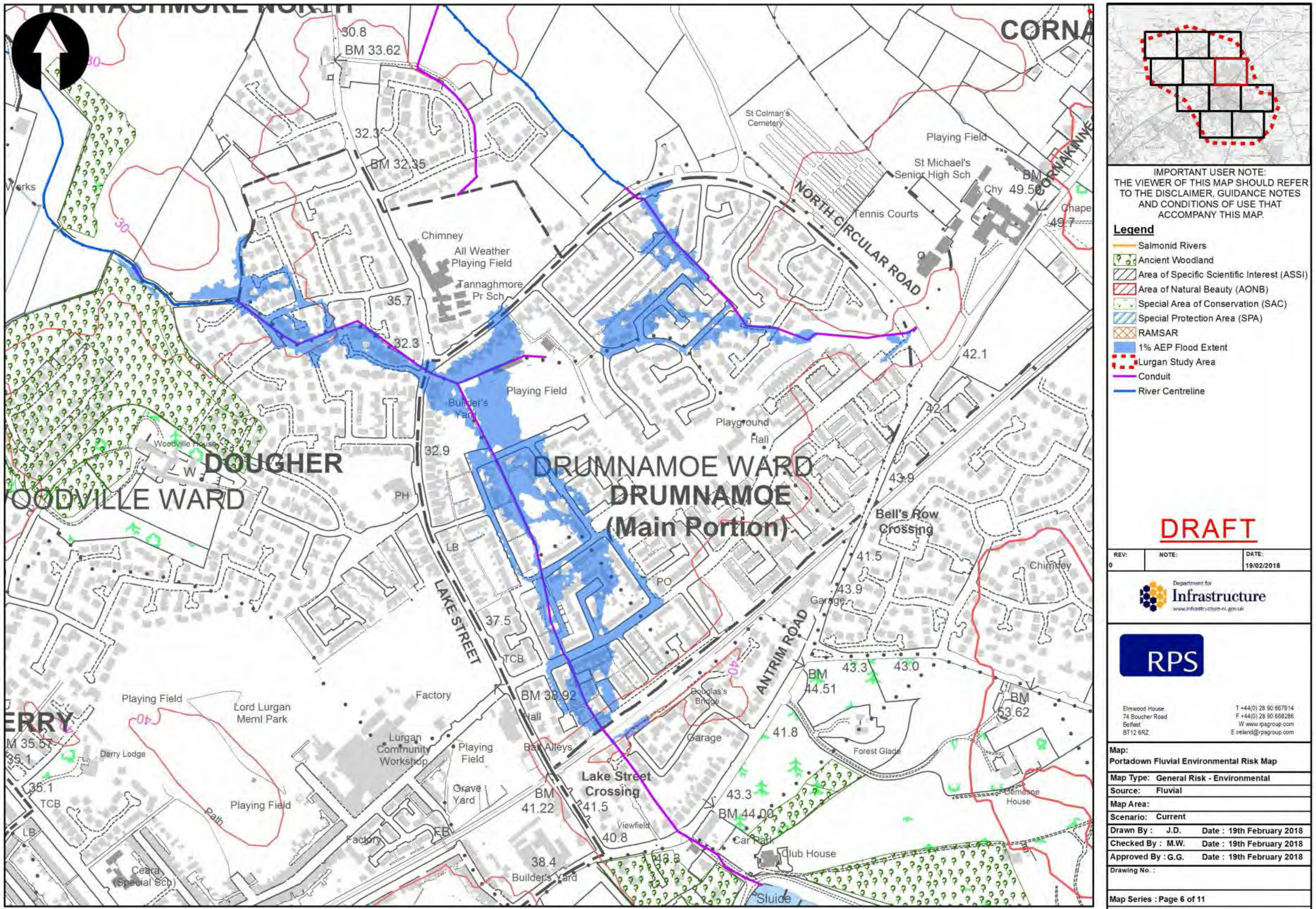

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Figure 2.7 - Summary of Flood Risk to Environmental Receptors in the Lurgan Study Area

2.6.4 Summary of Non-Monetised Risk

The following receptors in Table 2.16 were identified as at flood risk during the design flood event or at potential risk during the construction, maintenance and operation of the preferred option.

Table 2.16 – Summary of Non-Monetised Risk in Lurgan

Risk Category	**Receptor**	**Risk type**
Economic	168 residential properties	At risk from flooding
Economic	0 non-residential properties	No risk
Economic	Several roads including: 1 Motorway (M1) 1 A class (Millennium Way) 1 B class (Francis Street) 2 C class (Lake Street and Castor Bay Road) 47 Unclassified	At risk from flooding
Social	1 historic park and garden (Brownlow House at Lurgan Park)	At risk from flooding
Social	1 industrial heritage bridge (Taghnevan)	Listed buildings/structures at risk of damage or modification during construction, maintenance and operation.
Environmental	SPA - Lough Neagh and Lough Beg ASSI – Lough Neagh RAMSAR - Lough Neagh & Lough Beg Site Several areas of ancient woodland (classified as long-established woodland)	Impact to environmental designations to be considered during optioneering.

3 OBJECTIVES AND CONSTRAINTS

The following objectives and constraints have been identified from the project brief, reviewing the flooding mechanisms and the Flood Risk Assessment.

3.1 OBJECTIVES

The scope of services detailed the need to consider a wide range of flood alleviation options including short-term (0-5 years) measures and long-term (5+ years) measures for the Lurgan Study Area. The long term measures should alleviate potential future flooding and provide protection to properties currently at risk of flooding during events up to and including the 1% AEP flood event for the life time of the scheme. The primary objectives are therefore:

- Reduce the flood risk through short-term measures
- Provide the design SoP through long-term measures.

These remain the primary objectives of this study however other objectives and constraints have been identified from the flood risk assessment and are detailed according to the categories set out below.

3.1.1 Reduce the Flood Risk to Receptors in Lurgan

As discussed in Section 2.5, a damage assessment was carried out which determined that during a 1% AEP flood event, there are 168 properties which incur a monetary damage, all of which are residential properties. These properties are located within five discreet locations, mechanisms range from insufficient channel capacity, insufficient culvert capacity and/or surcharging manholes. The recommended options should seek to reduce this flood risk as much as possible.

3.1.2 Technical Objectives and Constraints

Technical objectives and constraints consider any factor that needs to be accounted for or that may cause limitations to the design, construction or maintenance of the proposed option. The following objectives or constraints have been identified:

- There should be no increase in flood risk to any other flood vulnerable receptor within Lurgan.
- The flood alleviation option should provide or be readily adaptable to provide future climate change protection.
- The flood alleviation option should have few and/or managed health and safety issues regarding construction, maintenance and operation.

3.1.3 Social Constraints

Social constraints consider any social receptor or receptor used for social purposes that may be affected by the design, construction and maintenance of the proposed option. The following objectives or constraints have been identified:

- Access to the parts of the study area would be via residential areas. The impact to residents would need to be considered during constructions, maintenance and operation.

- Some areas zoned for flood alleviation measures are private land. The proposed works would be proceeding under the goodwill of the private land owner. The proposed measures should have as limited impact as possible to the landowners current use of the land and also future use.
- Continued access to socially important receptors during flood events should be maintained. These include Lurgan Hospital, Fire Station, Police Station, Schools and Residential/Nursing Homes.

3.1.4 Environmental Constraints

Environmental constraints consider any environmental receptor or receptor with environmental significance that may be affected by the design, construction and maintenance of the proposed option. The following objectives or constraints have been identified:

- There are 3 designations at the downstream end of the study area towards Lough Neagh, these include an Area of Specific Scientific Interest (ASSI), Special Protected Area (SPA) and RAMSAR site. As such any works in these areas should be avoided.
- Areas of Ancient Woodland are present in proximity to the lake at Lurgan Park, as well as downstream on the Woodville watercourse near Woodville Gate, which should be considered during the optioneering process.

3.1.5 Economic Constraints

Economic constraints consider current cost to operations relative to the estimated costs of any proposed option in relation to the available budget and achieving value for money. The following objectives or constraints have been identified:

- As this project has been commissioned by a public organisation, the objective is to identify the most economically viable option and at a minimum have a benefit cost ratio (BCR) greater than unity.
- It is desirable if possible to prevent flooding to roads identified to be at risk.

4 OPTION DEVELOPMENT AND ANALYSIS

4.1 OPTION IDENTIFICATION

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

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

The main aim of the Lurgan study is to assess whether an economical, environmentally and socially sensitive scheme can be produced which will alleviate the flood risk to affected properties, infrastructure and businesses in the study area. This would, in general, entail providing 'protect' methods over 'prepare' methods and avoiding 'permit' methods where possible. Prevent methods should always be included to prevent an increase in future flood risk.

4.1.1 Shortlist of Options

The aim of the screening process is to ensure the widest possible range of flood management options are considered in the assessment process while the rejection of any methods shall be robust and with clear and transparent reasoning. The long list of methods considered is presented in Table 4.1 below.

Table 4.1 - Long List of Potential Methods

Option	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 (Temporary Defences)	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 planning policies.

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.
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 wash lands (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. Increasing the capacity of existing culverted watercourses.
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 suitable area.
Diversion of Flow	Protect	Removing flow from the watercourse via a diversion and discharging to a suitable river or coastline or reintroducing the flow further downstream. This may consist of a culvert, an open channel or using the existing topographical features of the floodplain to convey out of bank 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	Protect	Preventing pressurised culverts from surcharging through manholes and flooding the surrounding area.
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 methods such as flood gates, vent covers, use of flood resilient materials, raising electrical power points, etc.

Each of these methods has been reviewed against its applicability for the Lurgan area and those which are obviously unsuitable have been removed. Table 4.2 below indicates those methods which have been included and excluded.

Table 4.2 - Applicable list of methods to the Lurgan Study Area

Option	Review Comment	Applicable?
Do Nothing	Required to maintain the watercourses and remove blockages etc. under the requirements of the Drainage (Northern Ireland) Order 1973. Therefore cannot carry out the Do Nothing or walk away method.	×
Maintain Existing Regime	Baseline condition, consider further.	✓
Do Minimum (Temporary Defences)	Consider further.	✓
Planning and Development Control	Consider further.	✓
Land Use Management	Consider further.	✓
Maintenance Programme	Consider further.	✓
Upstream Storage/Storage	Consider further.	✓
Tidal Barrage	Not applicable - principle source of flooding is fluvial.	×
Improvement of Channel Conveyance	Consider further.	✓
Hard Defences	Consider further.	✓
Relocation of Properties	Consider further.	✓
Diversion of Flow	Consider further.	✓
Sealing Manholes	Consider further.	✓
Flood Warning/Forecasting	Consider further.	✓
Public Awareness Campaign	Consider further.	✓
Individual Property Protection	Consider further.	✓

4.1.2 Technical Review of Options

All methods which have been considered as applicable are reviewed on their technical merits and their ability to alleviate the specific mechanisms of flooding that exist in the Lurgan area. This is based on engineering judgement, information from DfI Rivers staff, flood mapping and through review of animations output from the hydraulic model. The following sections give a technical review of all applicable methods. The methods have been considered according to their flood cells where appropriate (see Figure 2.1) and flooding mechanisms which are:

Flood Cell 1. Knocknashane
Flood Cell 2. Shankill
Flood Cell 3. Kiln Lodge
Flood Cell 4. North Circular Road
Flood Cell 5. Drumnamoe

4.1.2.1 Additional Maintenance

This method considers whether improvements can be made to augment the existing maintenance regime which will provide a significant beneficial impact on flood risk in the area. A review was carried out of the existing watercourse network. This included assessing the channel vegetation, the amount of debris present in the channels and the likelihood of structures becoming blocked. Although additional maintenance could be carried out, it was concluded that this would not help to reduce the risk of flooding to receptors in Lurgan in any of the flood cells and so was not considered further within this study.

4.1.2.2 Temporary Defences

This option includes interim methods which could be implemented as a short-term flooding solution, such as sand bags or small earth bunds, to offer protection to individual properties. A review was carried out to identify suitable areas for temporary defences. This review considered the flow path of the flood waters and the depth of water at various locations. To avoid the risk of sudden failure, depths of over 0.6m were considered unsuitable for temporary defences.

<u>Flood Cell 1</u>

Temporary Defence methods such as sandbags would be technically suitable for the flooding experienced within Flood Cell 1, as the flood depths are less than 0.6m (the maximum level at which sandbags are considered effective). Sandbags work most effectively if joined together and placed on footpaths surrounding properties, although in Flood Cell 1 this is not possible as properties flood from the rear. Therefore it may be less straightforward to deploy sandbags to protect the properties identified at risk within flood cell 1, sandbags would be required around three sides of some properties as shown in Figure 4.1.

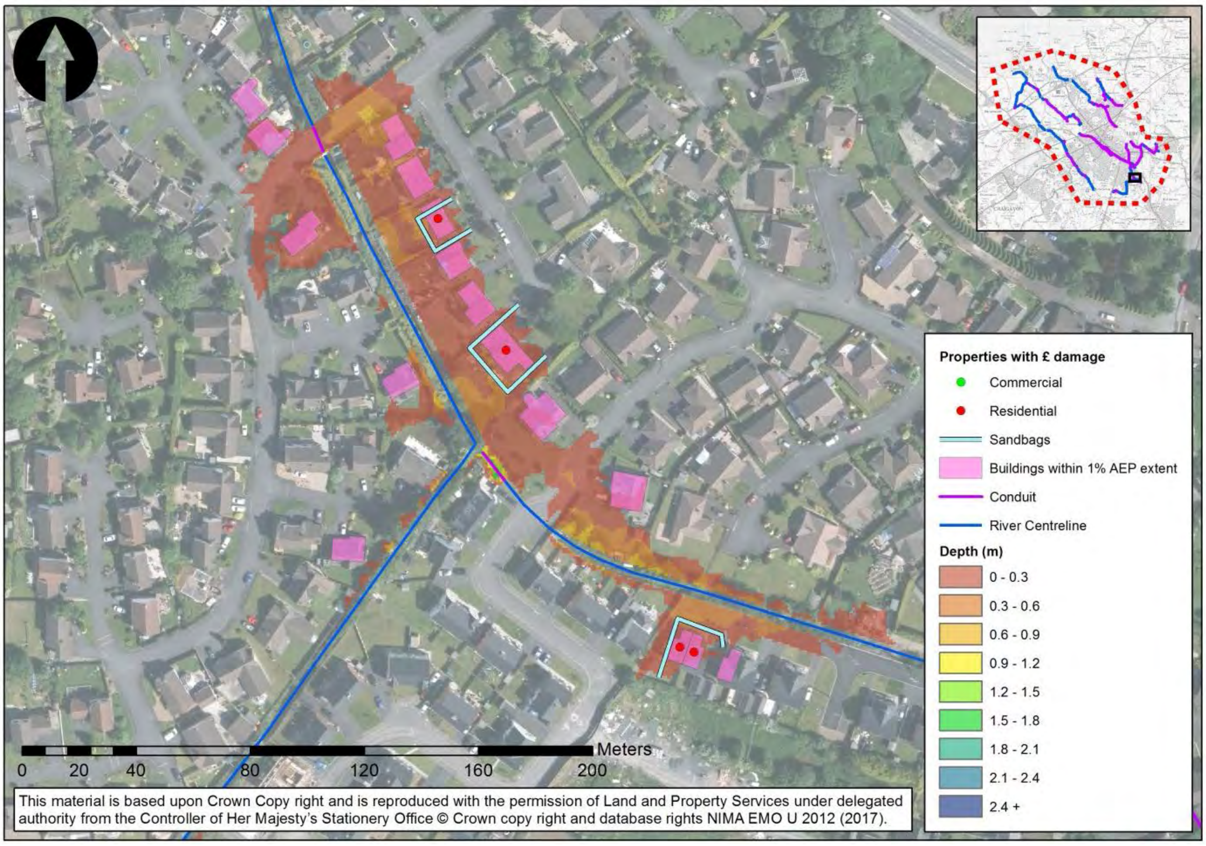

Figure 4.1 - Potential for use of sandbags on Shane Park and Knocknashane Park, Flood Cell 1

Flood Cell 2

Sandbags are not considered to be appropriate for Flood Cell 2. Figure 4.2 shows 7 terrace properties identified to be at risk on Deans Walk and 2 semi-detached properties at risk on Glebe Terrace. The sandbags aimed to protect the properties on Deans Walk are likely to divert flooding along roads around the properties, which is likely to increase flood risk for surrounding properties. The semi-detached properties are identified to be surrounded by flooding in the 1% AEP event, which would require the properties to be ring-fenced by sandbags. Although technically feasible this is not favourable due to restricted access. Figure 4.3 shows properties at risk further downstream in Flood Cell 2; this area is more suited to temporary defences, where sandbags could be placed along footpaths. Overall this method is not found to be suitable for all properties identified at risk in Flood Cell 2.

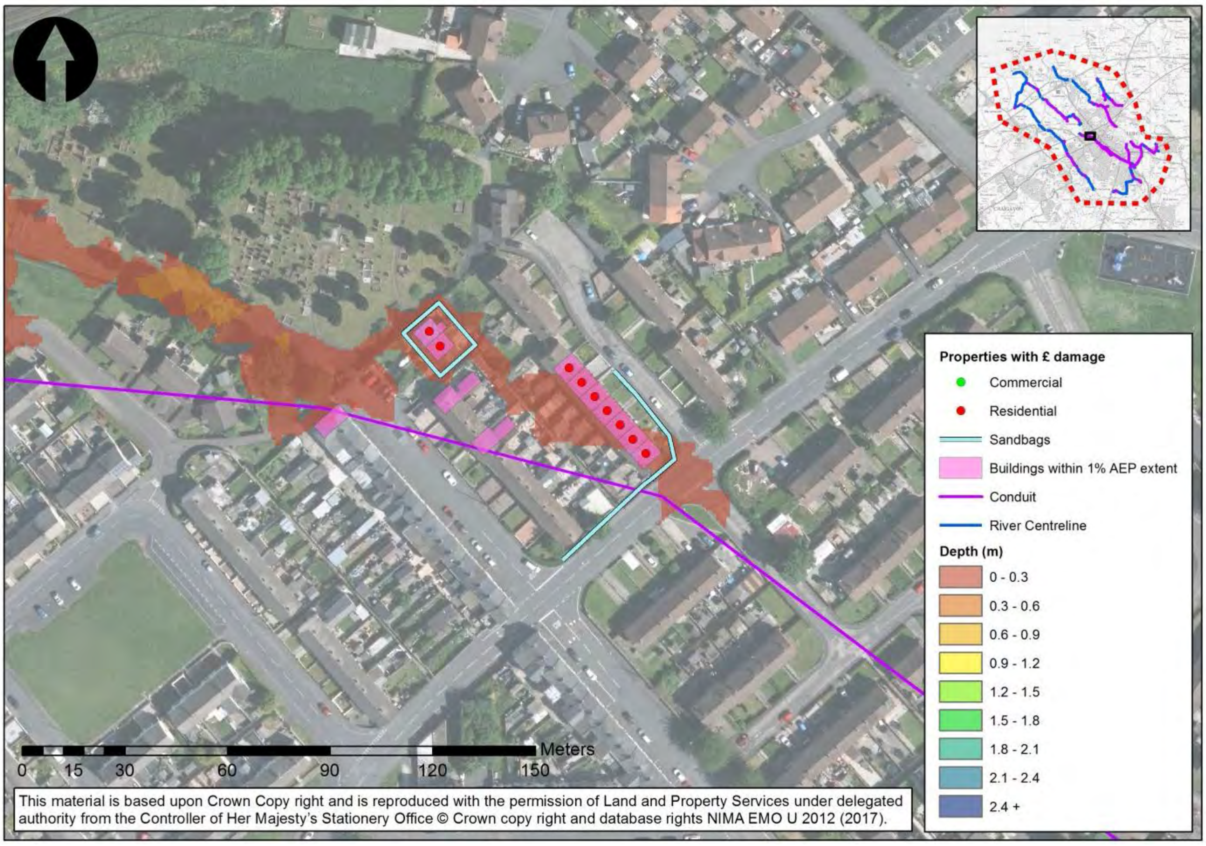

Figure 4.2 – Potential for use of sandbags on Deans Walk and Glebe Terrace (Flood Cell 2)

Figure 4.3 - Potential for use of sandbags on Beaumont Square (Flood Cell 2)

Flood Cell 3

Within flood cell 3, an individual property is identified to be at risk. As the depth of flooding is less than 0.6m sandbags are suitable for use as a temporary defence. Sandbags would be required to surround the rear of the property, as identified in Figure 4.4.

Figure 4.4 - Potential for use of sandbags on Kiln Lodge (Flood Cell 3)

Flood Cell 4

The extent of flooding within flood cell 4 is more extensive than in flood cells 1 to 3. The depth of flooding is found to be less than the threshold value of 0.6m. However due to the complex arrangement of temporary defences (as shown in Figure 4.5) that would be required, this method is not deemed suitable for Flood Cell 4.

Figure 4.5 - Potential for use of sandbags on residential area off North Circular Road (Flood Cell 4)

Flood Cell 5

In the Lurgan Study Area, the predominant flood risk is located within Flood Cell 5. Temporary defence methods would not be suitable for the majority of at risk properties within the flood cell due to the expansive flood extents, as shown in Figure 4.6. Some properties at risk towards the north of the flood cell may be suitable. However many of these properties would require defences which virtually surround the properties, causing access issues. Therefore due to the complex arrangement of temporary defences that would be required, this method is not deemed suitable for Flood Cell 5.

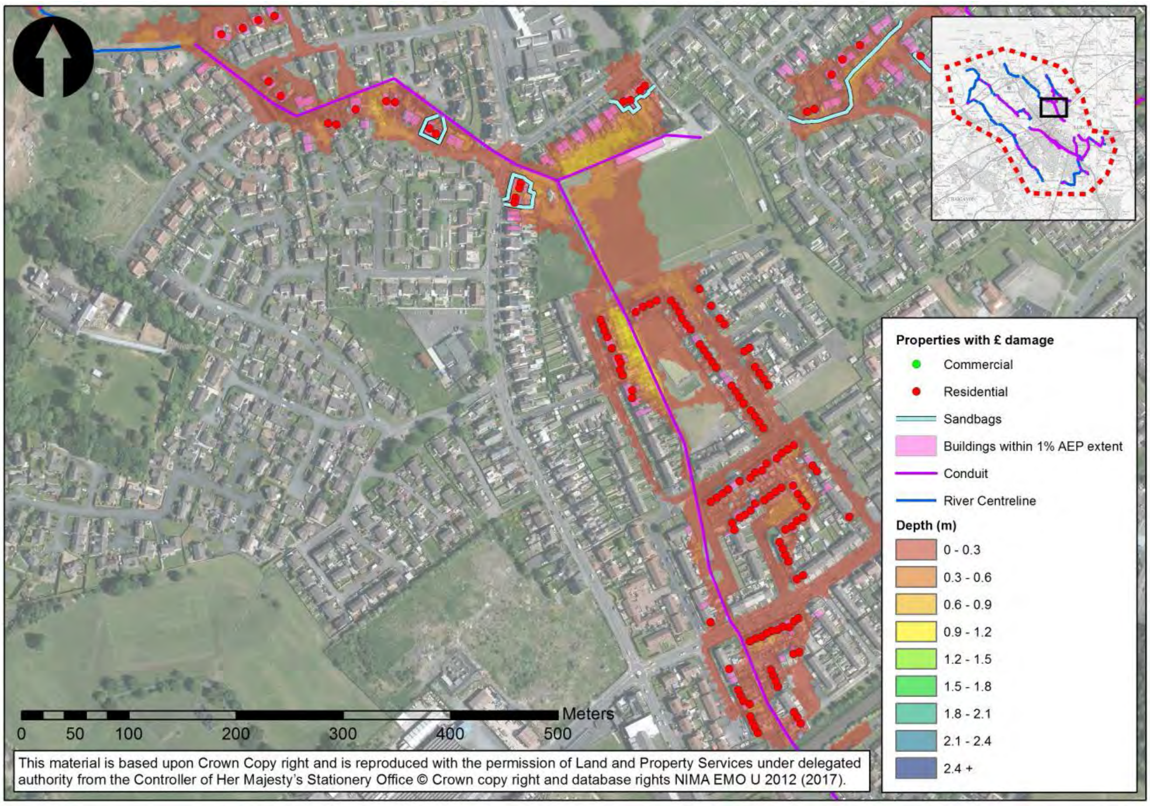

Figure 4.6 - Potential for use of sandbags on Drumnamoe Ave and Kilwilke Gardens

4.1.2.3 Planning and Development Control

Lurgan's urban area is already largely developed so this method may not help resolve flooding issues. There are several areas zoned for development within Lurgan Study Area as shown in Figure 4.7 and Figure 4.8. The zoned areas in Tannaghmore North and Dougher encroach onto the current 1% AEP event. Consideration should be given as to whether development within the floodplain is justifiable. Appropriate planning should be applied to ensure no future receptors are at risk from flooding in the 1% AEP event.

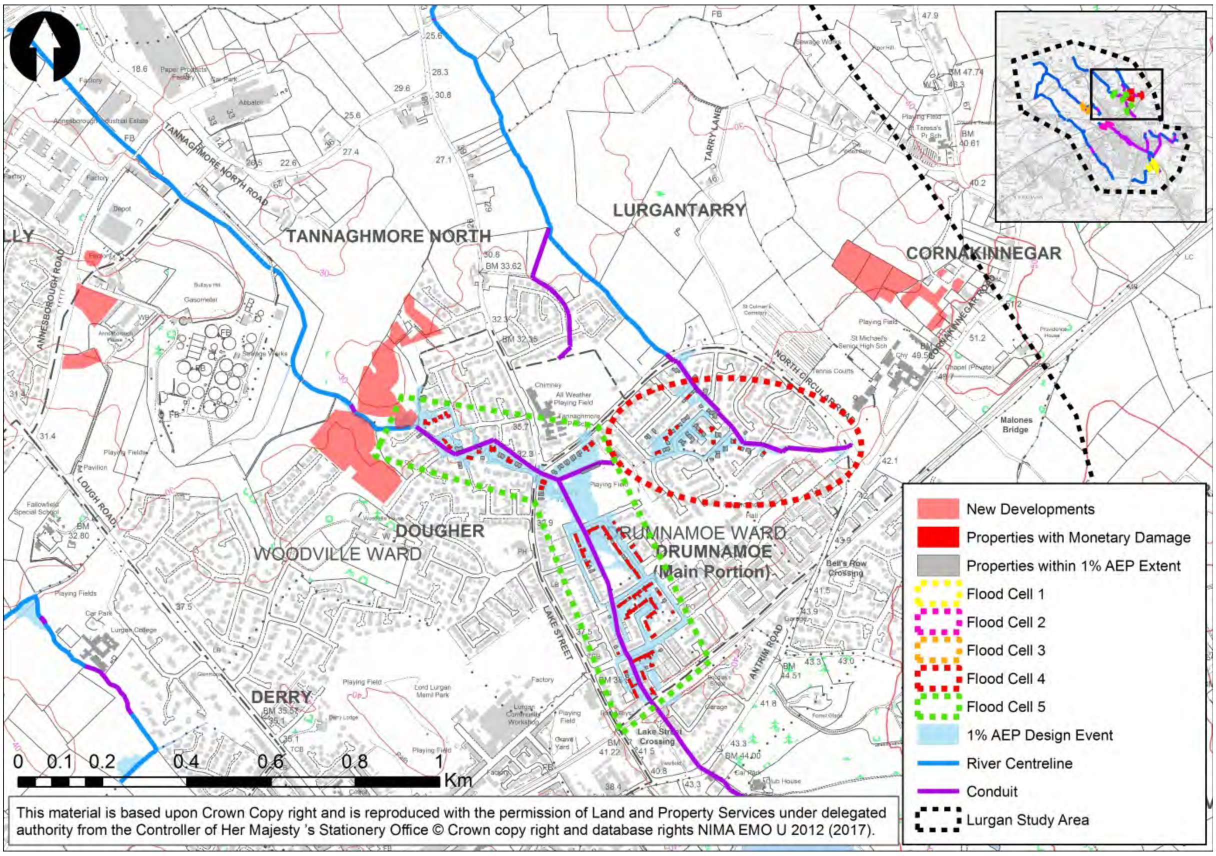

Figure 4.7 - Areas zoned for development within Lurgan Study Area – Drumnakelly, Tannaghmore North, Dougher and Cornakinnegar

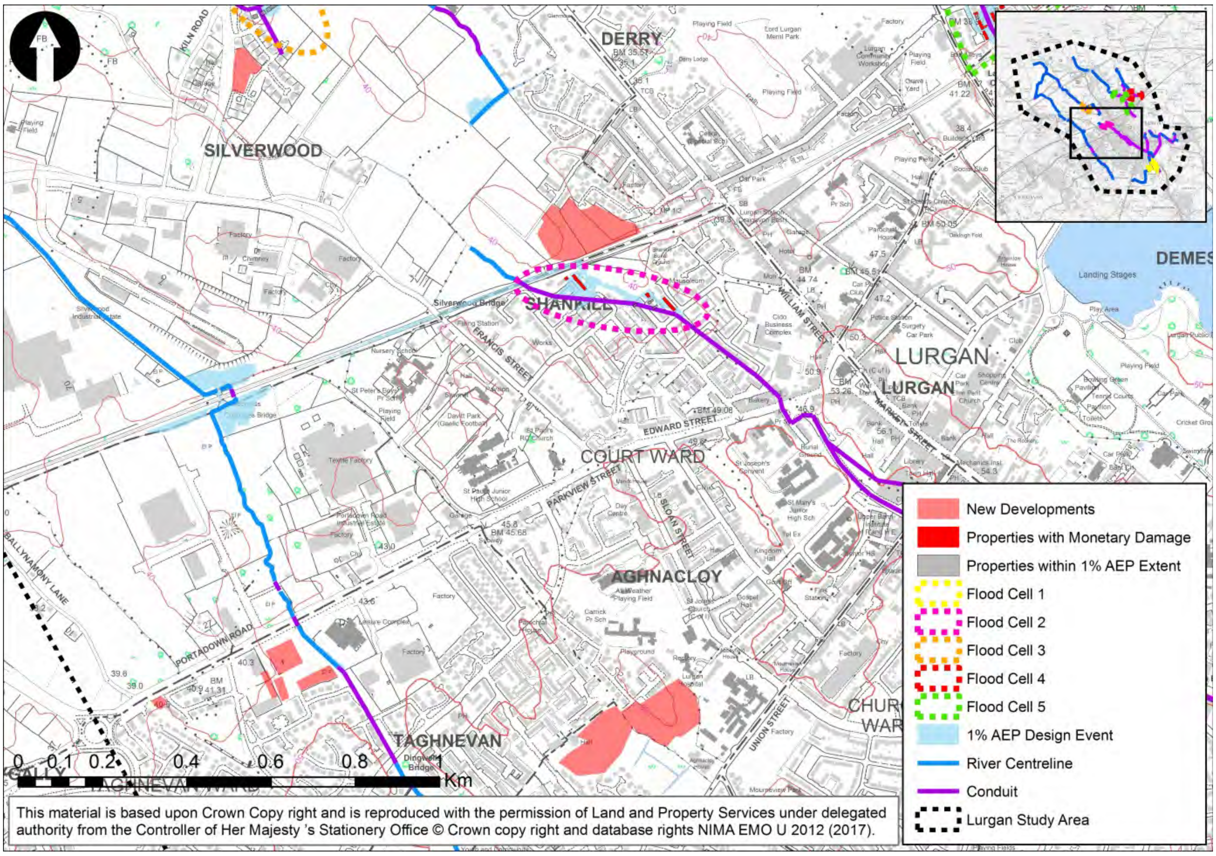

Figure 4.8 - Areas zoned for development within Lurgan Study Area – Silverwood, Shankill, Taghnevan and Aghnacloy

4.1.2.4 Land Use Management

Forest Research which is the Research Agency of the Forestry Commission has undertaken significant research into opportunities for woodland creation to reduce flood risk in Northern Ireland. One map which Forest Research have produced (shown as Figure 4.9) shows high priority areas for planting floodplain, riparian, and wider catchment woodland to reduce downstream flood risk. A total of 2,493 km^2 or 17.6% of Northern Ireland is identified as priority areas for woodland planting to reduce downstream flood risk, comprising 1,721 km^2 for wider woodland, 110 km^2 for riparian woodland and 663 km^2 for floodplain woodland. Currently, only 4.7% of Northern Ireland's floodplain is covered with woodland. Almost 44% of the floodplain is free from constraints to woodland planting, highlighting opportunities to significantly increase the floodplain woodland cover in Northern Ireland, from 71 km^2 to 663 km^2.

The modelled catchments in the Lurgan study area are found to be complex, with significant portions of watercourses culverted through urban areas. The delineated catchments for Lurgan are presented in Figure 4.10. The predominant land use in areas of risk and catchments upstream of these locations were found to be urban (continuous or discontinuous). Urban areas are limited in their potential for land use change and ultimately increasing infiltration and attenuation of overland flooding. There is limited scope for land use management to be a viable option as a flood alleviation option in Lurgan.

From assessing historic maps of Lurgan, significant development of residential areas has occurred since the 1950's. The historic land classification in the majority of these areas was found to be of agricultural use or historic orchards/nurseries. These areas would have previously reduced flood risk by attenuating flows, however are now likely to increase catchment response in terms of peak flows experienced due to increase runoff brought about by paved areas. Many of the areas identified to be at risk in the 1% AEP event have been constructed since the 1950's.

To demonstrate the significant land use change which has occurred in Lurgan, the area of predominant flood risk in the study area (flood cells 4 and 5) was investigated. Figure 4.11 shows significant areas of land use change, where properties identified at risk were previously undeveloped.

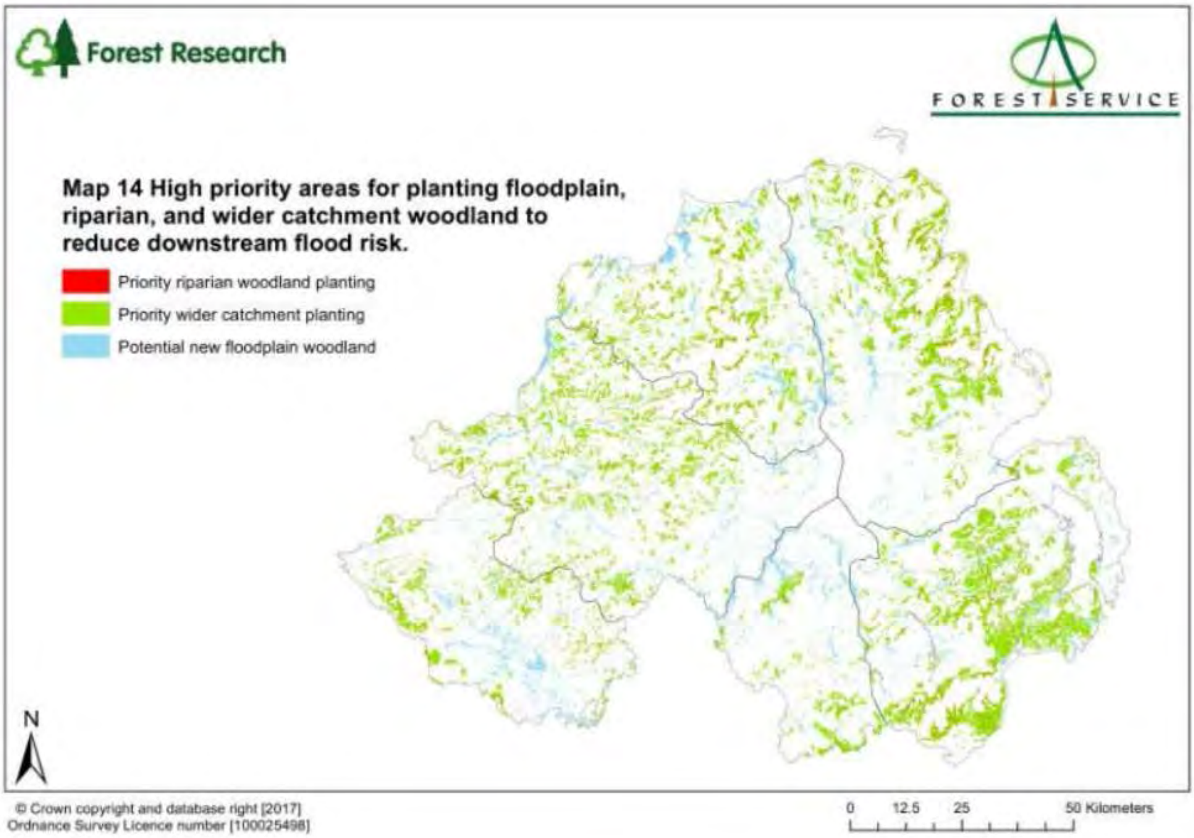

Figure 4.9 - High priority areas for planting floodplain, riparian and wider catchment woodland to reduce downstream flood risk

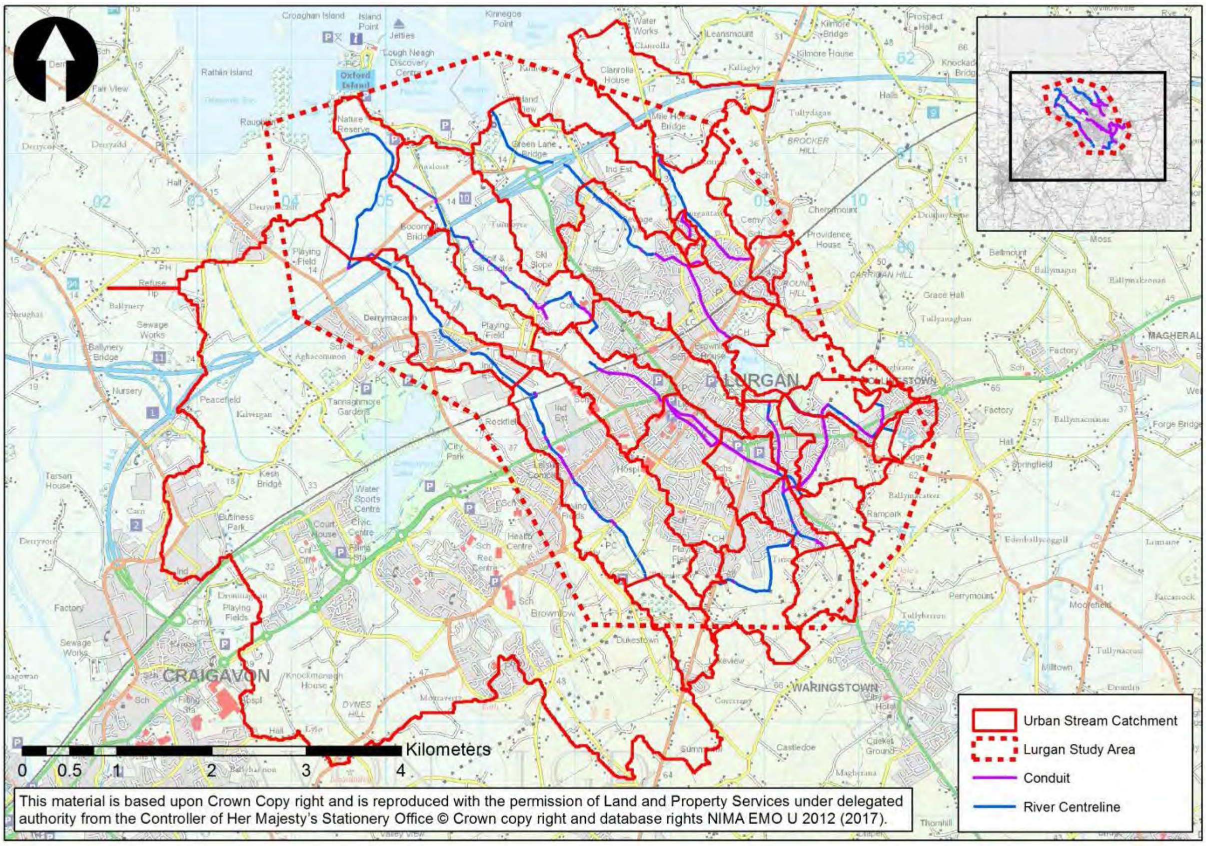

Figure 4.10: Catchment delineation for modelled watercourses in Lurgan study area

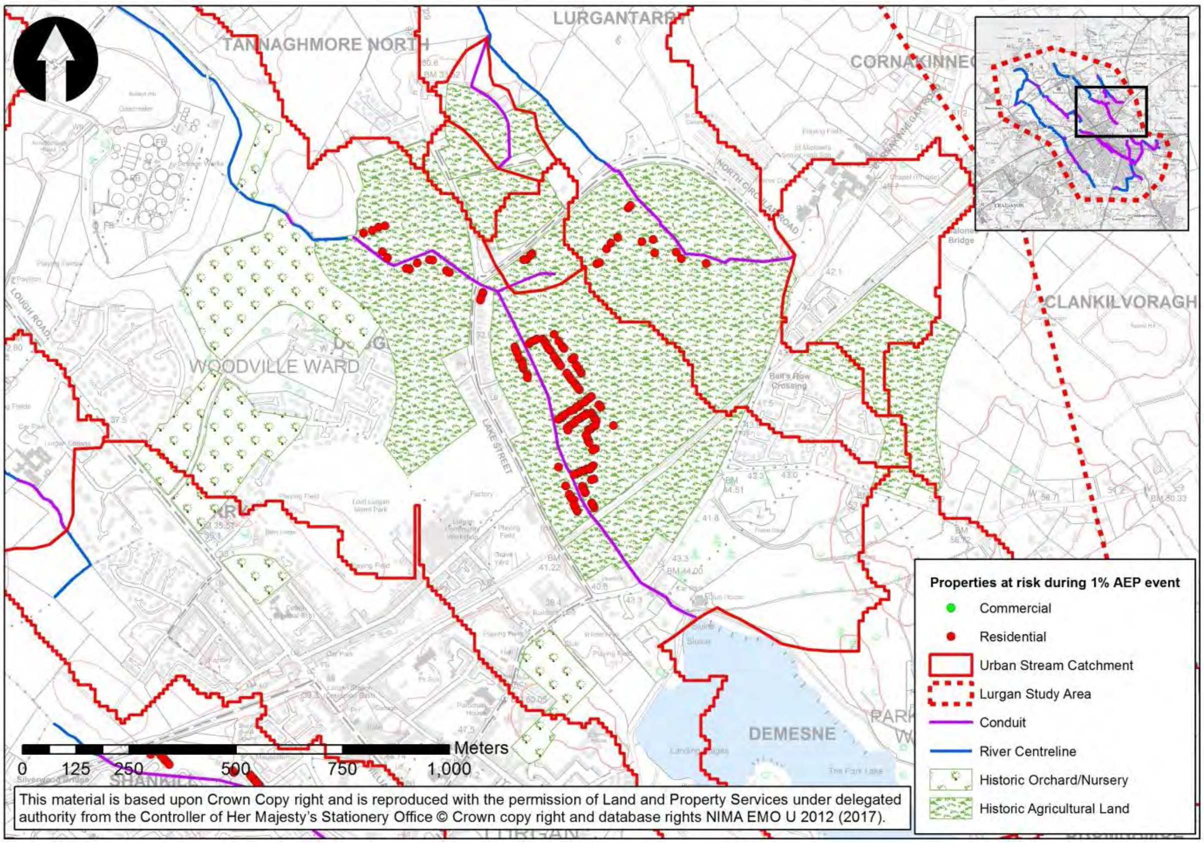

Figure 4.11: Drumnamoe area historic land use 1905-1957 and properties identified at risk during current 1% AEP event

4.1.2.5 Upstream Storage

This method considers areas where flood water can be stored and then released at a controlled rate therefore reducing the flow rate through the study area and reducing the level of flood risk. This can be achieved by using existing depressions to create online or offline storage areas or by identifying pinch points which could be dammed such as a restricted point along a valley. Storage areas can be effective either upstream of the risk areas or within the risk area where parks or open areas are located.

<u>Flood Cell 1 & 2</u>

A review was carried out to identify if there are any areas existing naturally in the topography upstream of flood cell 1 which may be suitable for storage. Flood cell 1 is located at the confluence of two watercourses (known as LURG11 and LURG13 within the model), both contribute flow, raising water levels and affecting properties within the flood cell. Potential storage locations were investigated on both watercourses.

A review of LiDAR information upstream of flood cell 1 along the LURG13 watercourse shows low lying land and potential natural storage locations (as shown in Figure 4.12). However LURG13 is only modelled for approximately 360m upstream of the flood cell and these storage locations are outside the extent of the model. No natural storage locations were found within the extents of the modelled LURG13 watercourse.

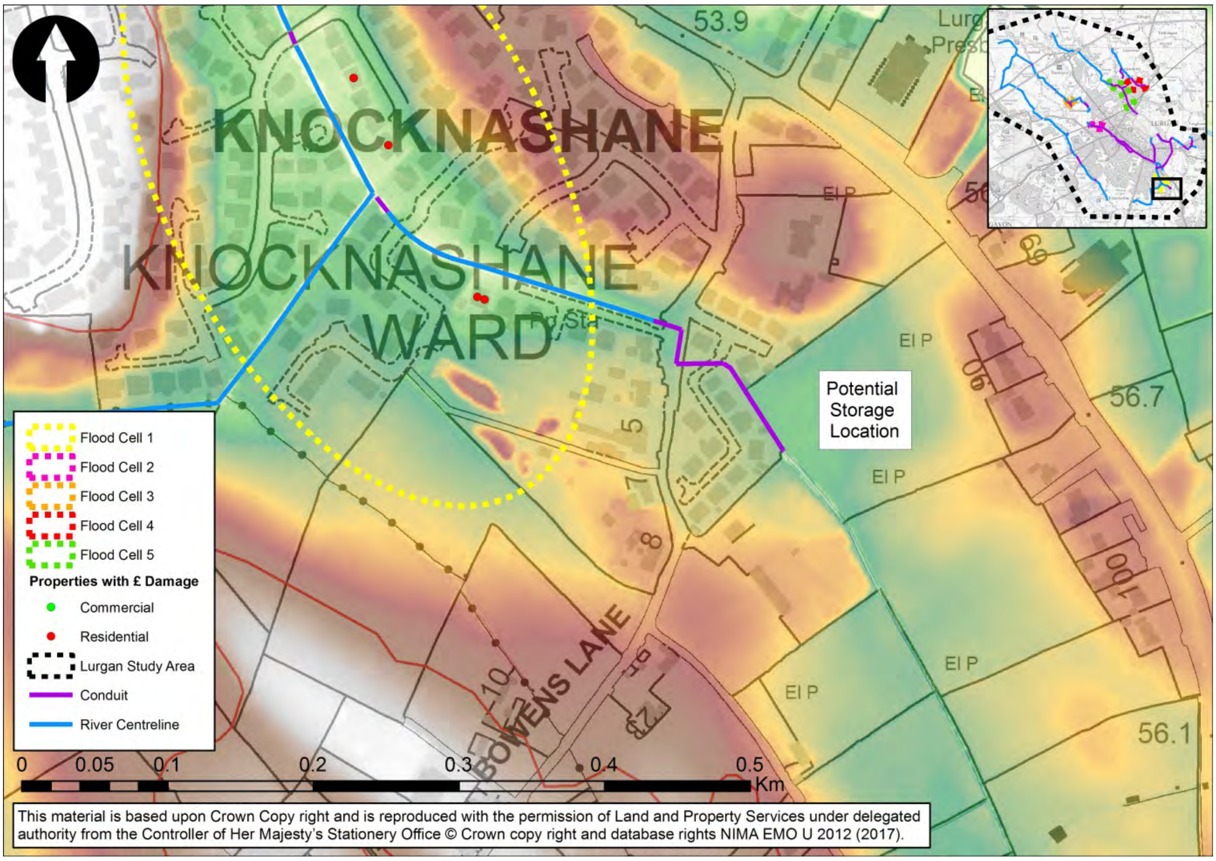

Figure 4.12 – Review of Topography for Potential Storage Locations on LURG13

The watercourse known as LURG11 flows from the Tirsogue area. An area of low lying rural land was identified on LURG11, where a bund could be placed across the river valley restricting flow through the use of control structures and therefore storing water upstream (see Figure 4.13). For this method to be technically feasible the flow passing through flood cell 1 would need to be reduced to the equivalent of a 4% AEP flood event. This would reduce out of bank flooding within the flood cell and properties would no longer be at risk. This scenario was simulated in a hydraulic model to determine its effectiveness.

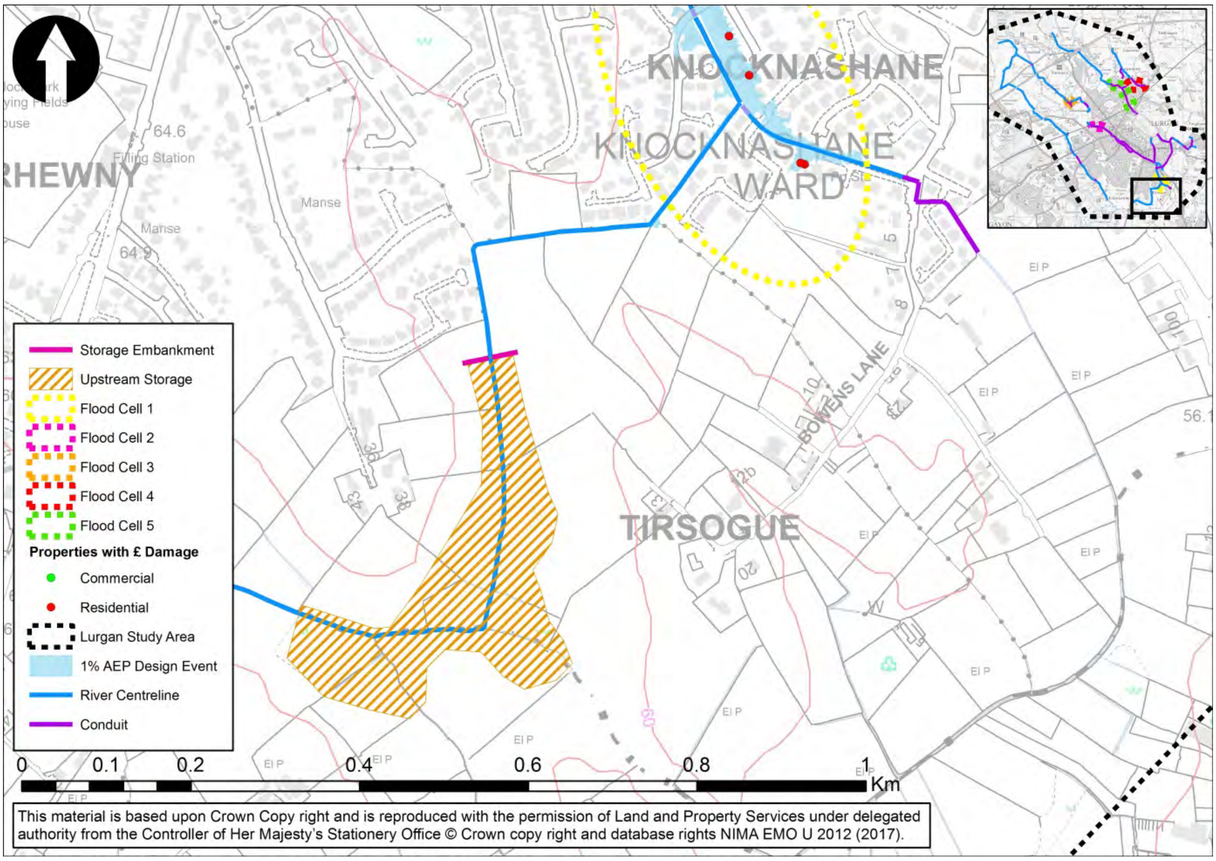

Figure 4.13 – Potential Storage Location on LURG11

A 60m long bund was placed across the LURG11 watercourse approximately 100m upstream from cross section LURG11_0300 to hold water back, forcing water levels to rise on the upstream extent of the bund which is acting as a dam structure. A control structure (circular, 0.4m diameter) was placed through the bund which allowed approximately 0.5m^3/s to leave the storage reservoir and continue down the LURG11 watercourse. This flow is the equivalent to allowing a 50% AEP flood event flow to continue down the watercourse resulting in a 10% - 4% AEP flow within flood cell 1.

Reducing the flow on the LURG11 watercourse was found to reduce water levels within flood cell 1, reducing out of bank flooding and protecting all 4 properties which are at risk during the 1% AEP event. It was also found that holding flow back on the LURG11 watercourse reduced flow downstream of flood cell 1 and benefitted properties at risk in flood cell 2. The flow within flood cell 2 was reduced enough to prevent manhole MH507 from surcharging. Manhole MH503 would continue to surcharge however no properties would be at risk. Therefore in addition to the properties within flood cell 1, the

16 properties at risk during the 1% AEP event within flood cell 2 would also benefit from the upstream storage area.

Figure 4.14 and Figure 4.17 below shows the difference in flood extents from the present day 1% AEP flood event and the upstream storage 1% AEP event simulation within flood cells 1 and 2.

Upstream storage is technically viable and will protect at risk properties during the 1% AEP event within flood cells 1 and 2. The measure is estimated to cost £241k which is economically viable. Note a price of £10,000 per acre has been assumed in the calculations for land acquisition. There are unknown social implications with purchase or renting of the land for a flood storage location, further information would be required from the land owner/owners and their participation in the flood relief scheme would need to be discussed. Therefore while the measure is technically and economically sound, in the event that negotiations over land acquisitions are not acceptable, secondary measures for both flood cells will also be brought forward to complete a separate option for the Lurgan Study Area.

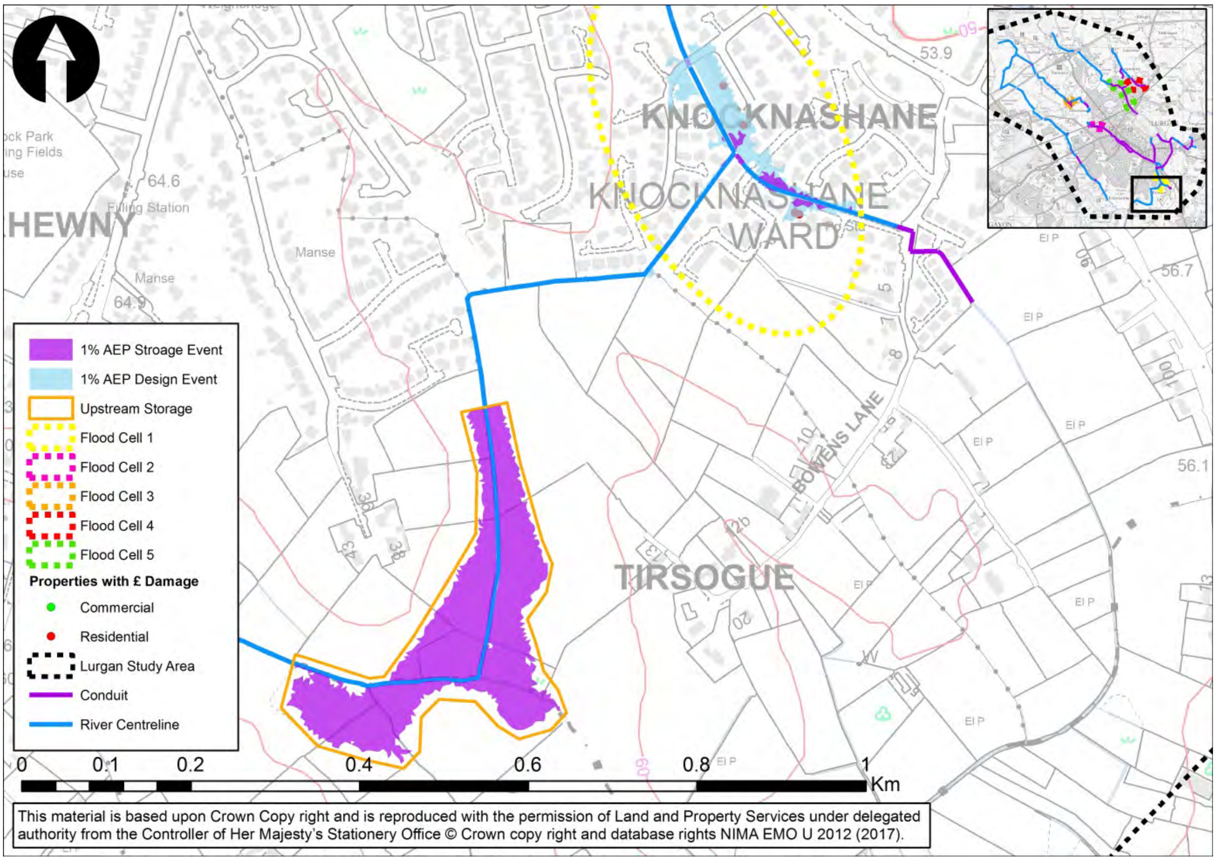

Figure 4.14 - Upstream Storage located on LURG11 Watercourse, Flood Risk in Flood Cell 1

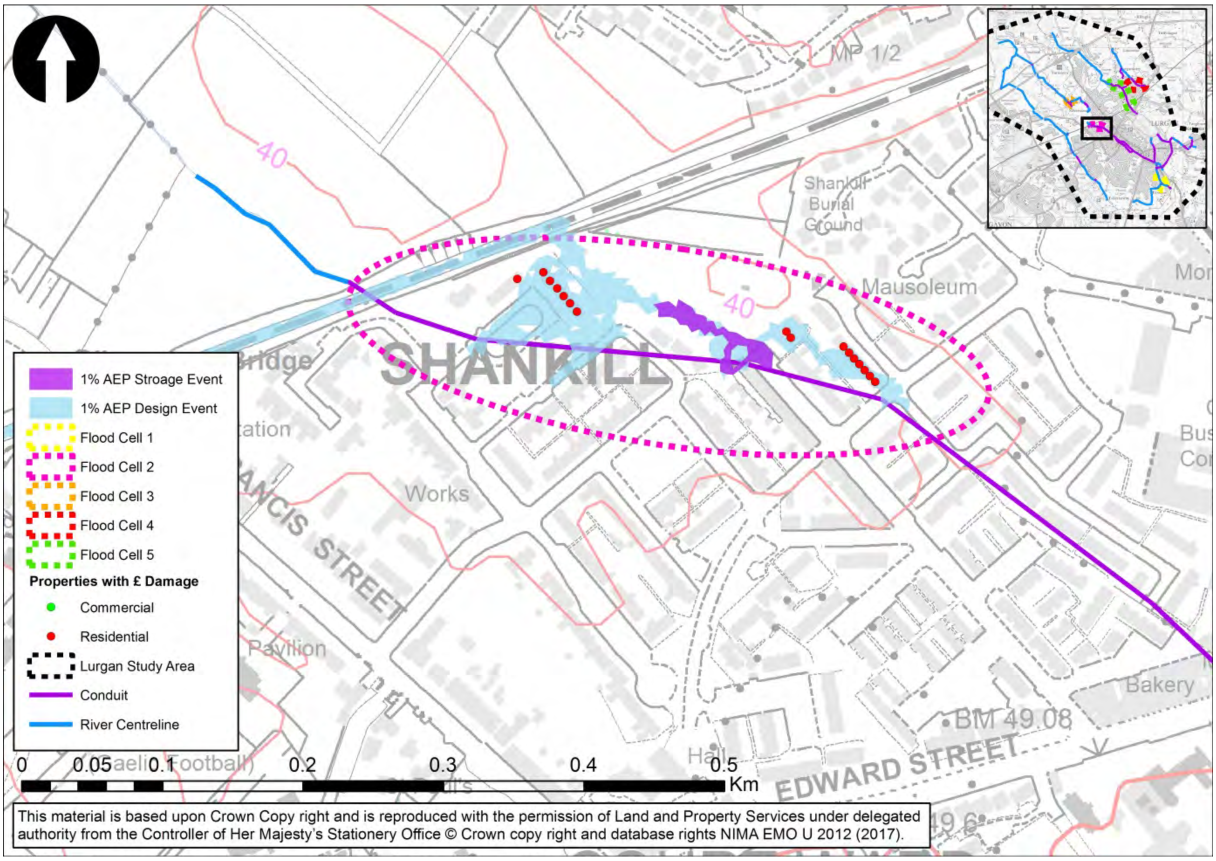

Figure 4.15 - Upstream Storage located on LURG11 Watercourse, Flood Risk in Flood Cell 2

Flood Cell 3

A review of LiDAR information upstream of flood cell 3 along the LURG08 watercourse shows low lying land and potential natural storage locations (as shown in Figure 4.16). A restrictive structure could be placed across the river reducing flow and causing out of bank flooding upstream on rural land. For this method to be technically feasible the flow passing through flood cell 3 would need to be reduced to the equivalent of a 1.33% AEP flood event. This would reduce out of bank flooding within the flood cell and the individual property would no longer be at risk. This scenario was simulated in a hydraulic model to determine its effectiveness.

A restrictive structure (circular, 0.9m diameter) was placed in the LURG08 watercourse approximately 25m upstream from cross section LURG08_0108 to hold water back, forcing water levels to rise upstream of the culvert. Due to the topography in the area a formal bund structure is not required, water backs up at the culvert inlet and flooding occurs upstream in low lying fields. The structure allowed 1.8m^3/s to continue down the LURG08 watercourse which is the equivalent of a 2% AEP flood event flow.

Reducing the flow on the LURG08 watercourse was found to reduce water levels within flood cell 3, preventing out of bank flooding and protecting the property which is at risk during the 1% AEP event. Figure 4.17 below highlights the difference in flood extents from the present day 1% AEP flood event and the upstream storage 1% AEP event simulation.

However the cost to implement this measure is approximately £81k, this is significantly more expensive than other technically viable measures for flood cell 3 and therefore this measure has been ruled out economically.

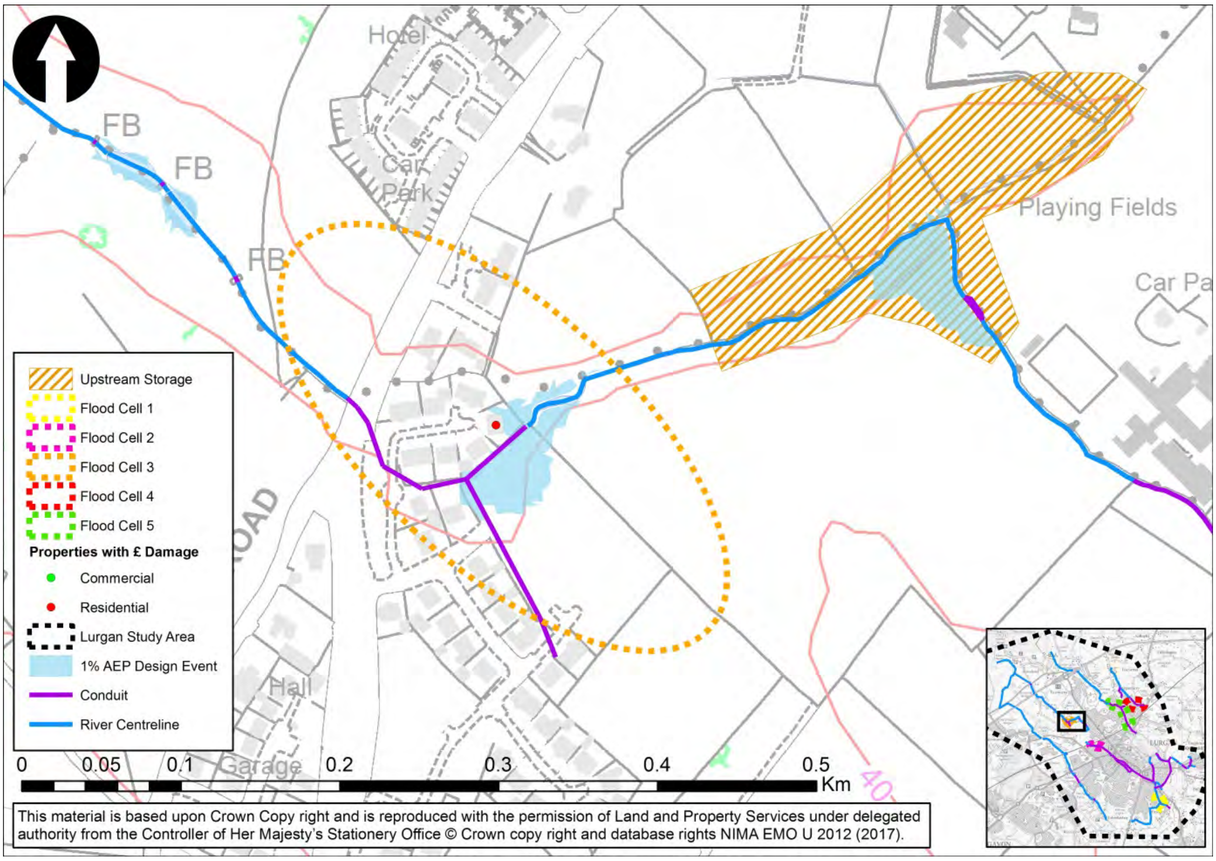

Figure 4.16 - Upstream Storage located on LURG11 Watercourse, Flood Risk in Flood Cell 2

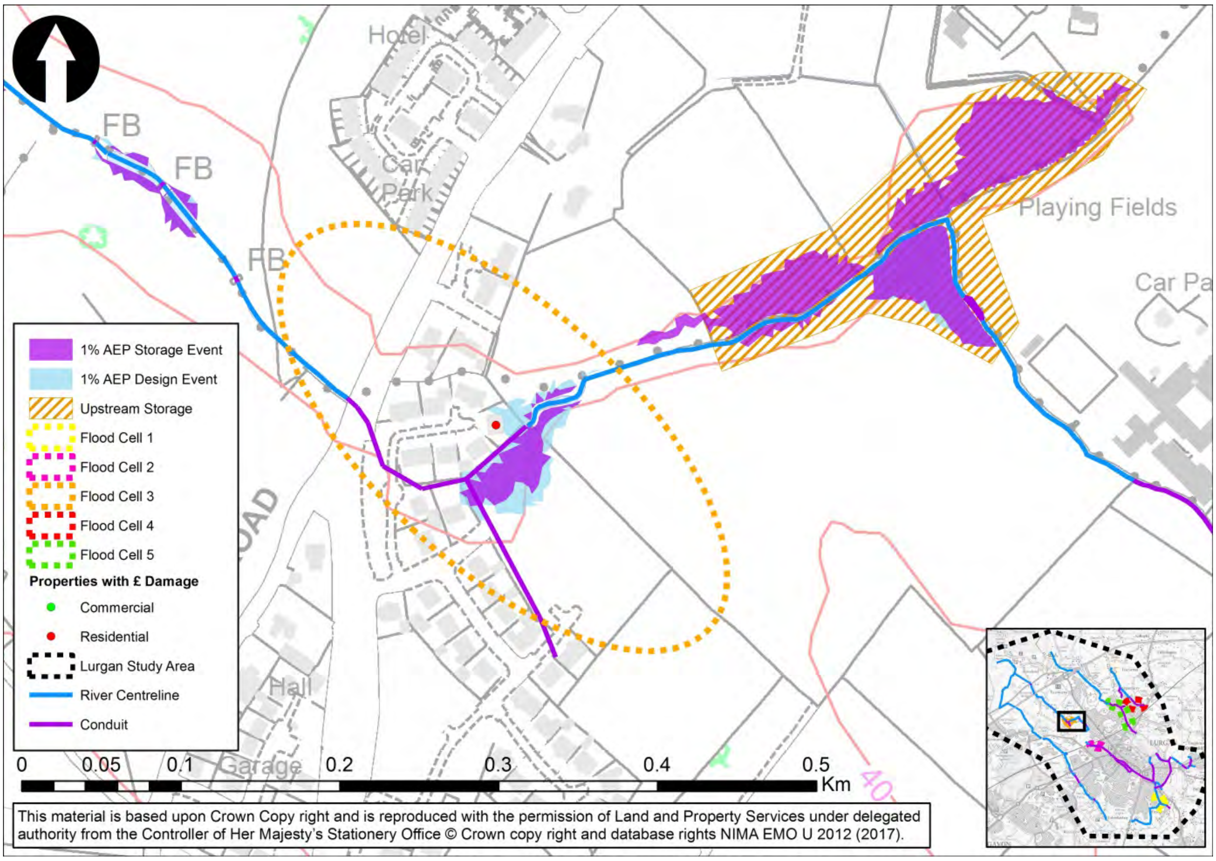

Figure 4.17 - Upstream Storage located on LURG11 Watercourse, Flood Risk in Flood Cell 2

<u>Flood Cell 4</u>

A review of topography upstream of flood cell 4 showed small areas of low lying land and potential natural storage locations (as shown in Figure 4.18). However the modelled watercourse does not extend far enough to cover these storage locations. No natural storage locations were found within the extents of the modelled watercourse, therefore storage is a technically unfeasible measure to benefit flood risk within flood cell 4.

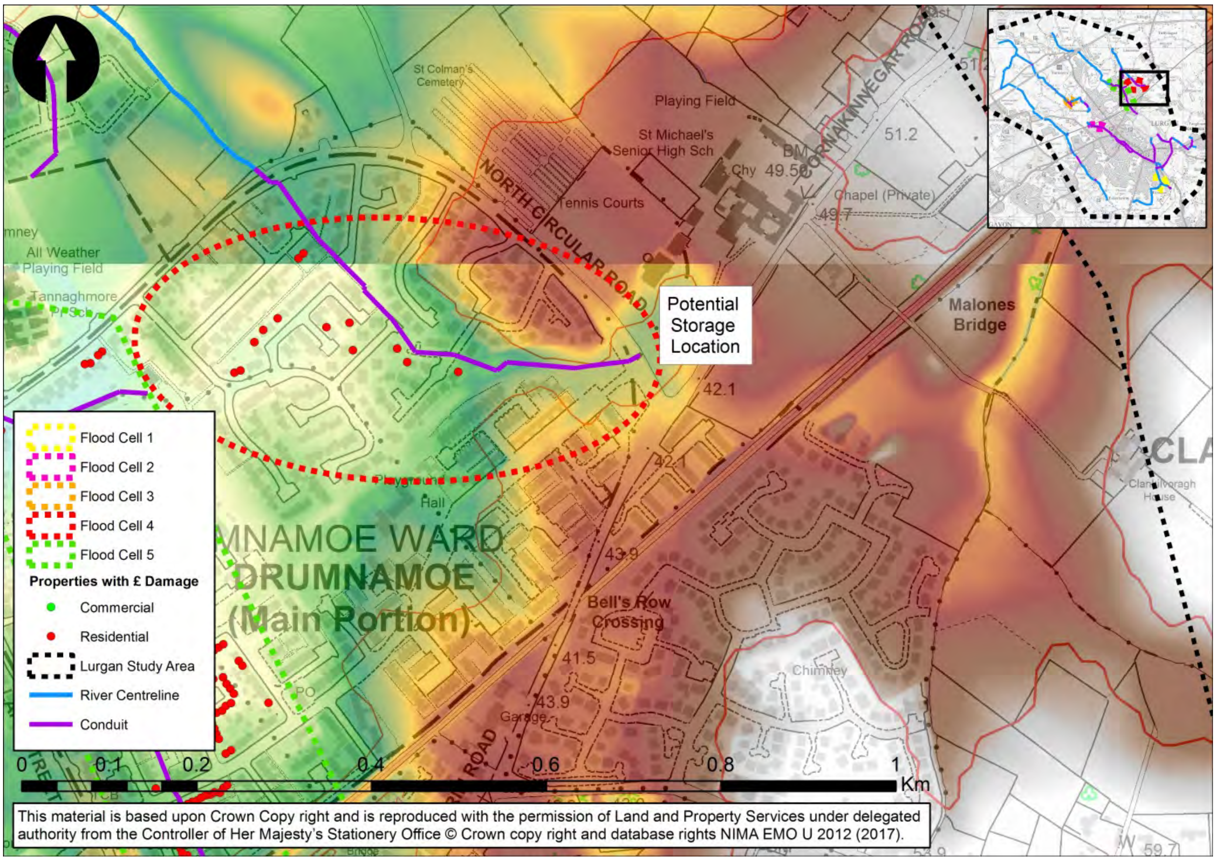

Figure 4.18 - Review of Topography for Potential Storage Locations Upstream of Flood Cell 4

Flood Cell 5

Flood cell 5 is located downstream of Park Lake, properties are at risk when manholes along a long culvert surcharge. Initially it was thought that Park Lake could provide additional storage however following investigation of the twin siphon control structure (as discussed in the Lurgan Modelling Report) it was found that the levels within Park Lake are maintained within a specific limit. It is thought Park Lake is acting as a reservoir with Windsor Avenue running alongside the North Western extent as a dam structure. At present there is not enough information known regarding the function of the siphon structure or its effect on Park Lake water levels to ascertain if the lake could be used to create additional storage to attenuate flow. No other locations were identified for potential storage to benefit flood cell 5.

4.1.2.6 Improvement of Channel Conveyance

This method focuses on increasing watercourse conveyance thereby lowering water levels and reducing the associated flood risk. This can be achieved by lowering the bed level, widening/reshaping channels, removing channel/structure constrictions, culverting reaches of watercourse or upgrading existing culverts and reducing roughness of the channel.

Flood Cell 1

A review of water levels within flood cell 1 showed that two culverts, LURG13_0000in and TD_Culvert_1_us were restricting flow and causing water levels to rise. Consequently flooding occurs from both banks and affects 4 properties within the 1% AEP event. Figure 4.19 shows the long section and flood extents during the 1% AEP event.

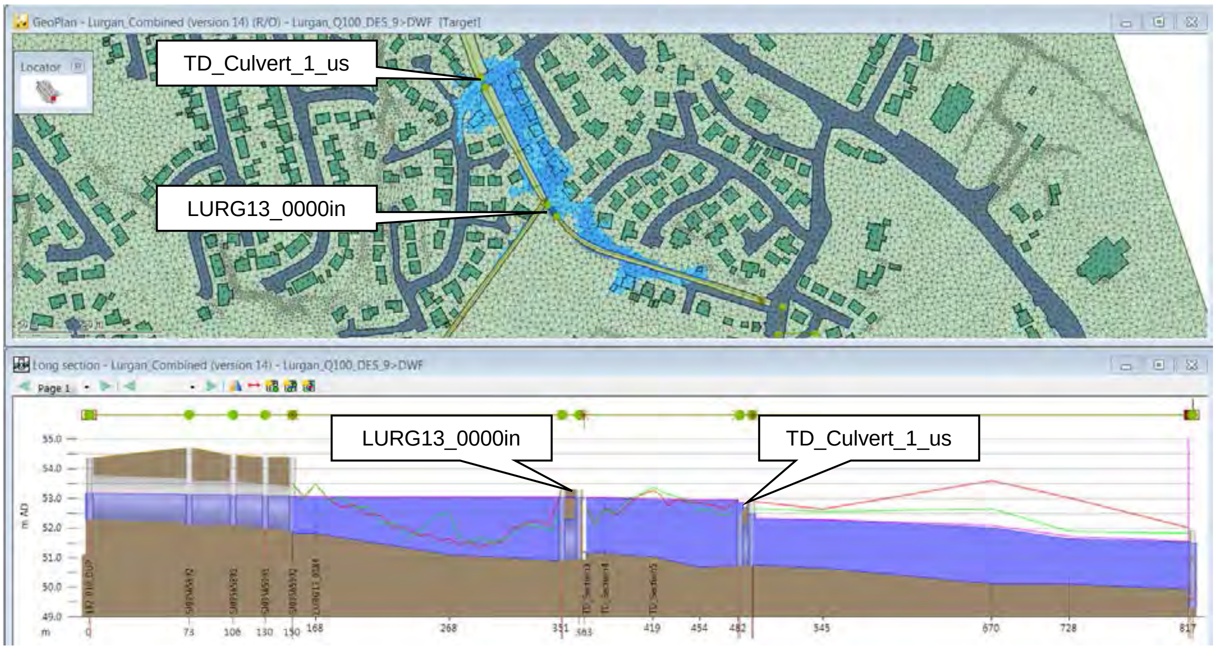

Figure 4.19 – Restrictive Culverts within Flood Cell 1 during the 1% AEP Event

Based on review of the channel size and shape it was noted there was potential to upgrade the culverts which are both sized as 1350mm pipes, to 2100mm pipes. A hydraulic model was run to simulate the effect of upgrading the culverts. As shown in Figure 4.20 while the culvert upgrades do significantly reduce water levels and out of bank flooding some properties are still at risk of flooding during the 1% AEP event. To further increase the culvert sizes, channel widening and deepening would be required however the channel is located between housing estates (as shown in Figure 4.21) and there is little opportunity to increase the channel width. Channel dredging would also be restricted by the invert levels of culverts located upstream and downstream of flood cell 1. Therefore while improvement of channel conveyance is possible and does benefit some properties within flood cell 1, it has been removed as potential measure as some properties will remain at risk.

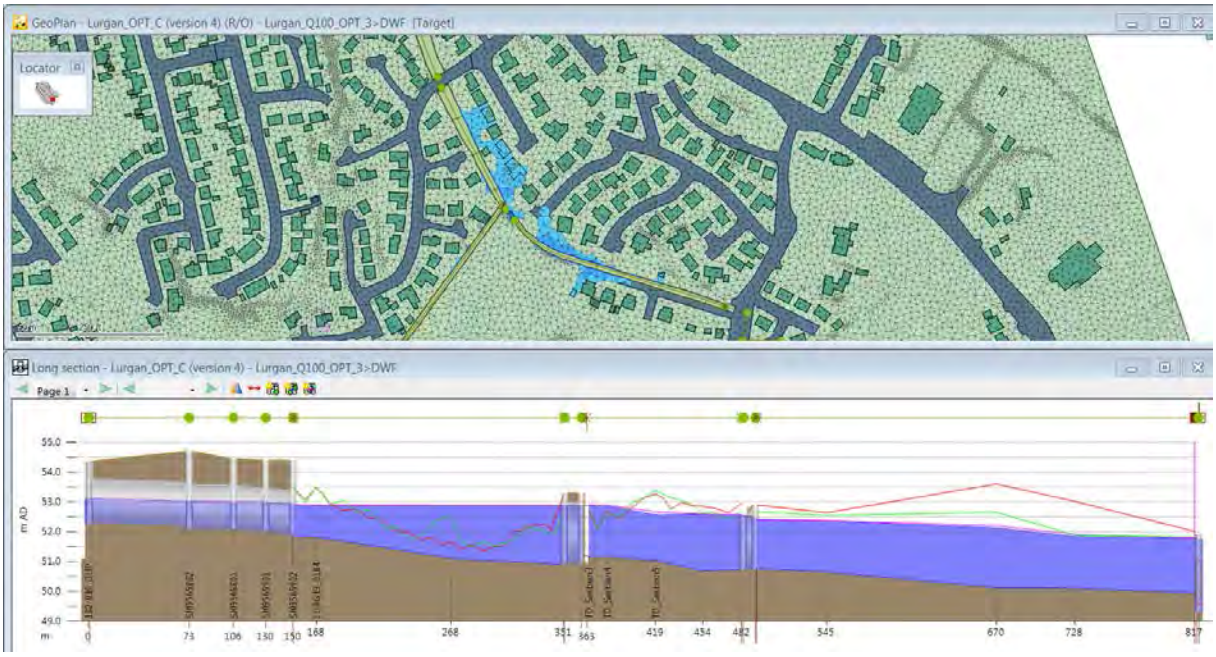

Figure 4.20 – Culverts upgraded to 2100mm pipes within Flood Cell 1 during the 1% AEP Event

Figure 4.21 – LURG143 Channel

<u>Flood Cell 2</u>

There is potential for improvement of channel conveyance within flood cell 2. The flood cell is located at the downstream extent of a long culvert which flows through Lurgan town centre. In the location of flood cell 2 the culvert is undersized (culvert size ranges from 525mm to 675mm) and manholes surcharge creating overland flow paths which affects 16 properties within the 1% AEP event. Figure 4.22 shows the extent of the culvert which would need to be upgraded to a 900mm pipe from manhole MH665 to end. A hydraulic model was constructed to simulate the culvert upgrade, with the additional culvert capacity no manholes surcharged and all properties were protected during the 1% AEP event. Therefore improvement of channel conveyance is a technically feasible measure for flood cell 2.

However the cost to implement this measure is approximately £347k, this is significantly more expensive than other technically viable measures for flood cell 2 and therefore this measure has been ruled out economically.

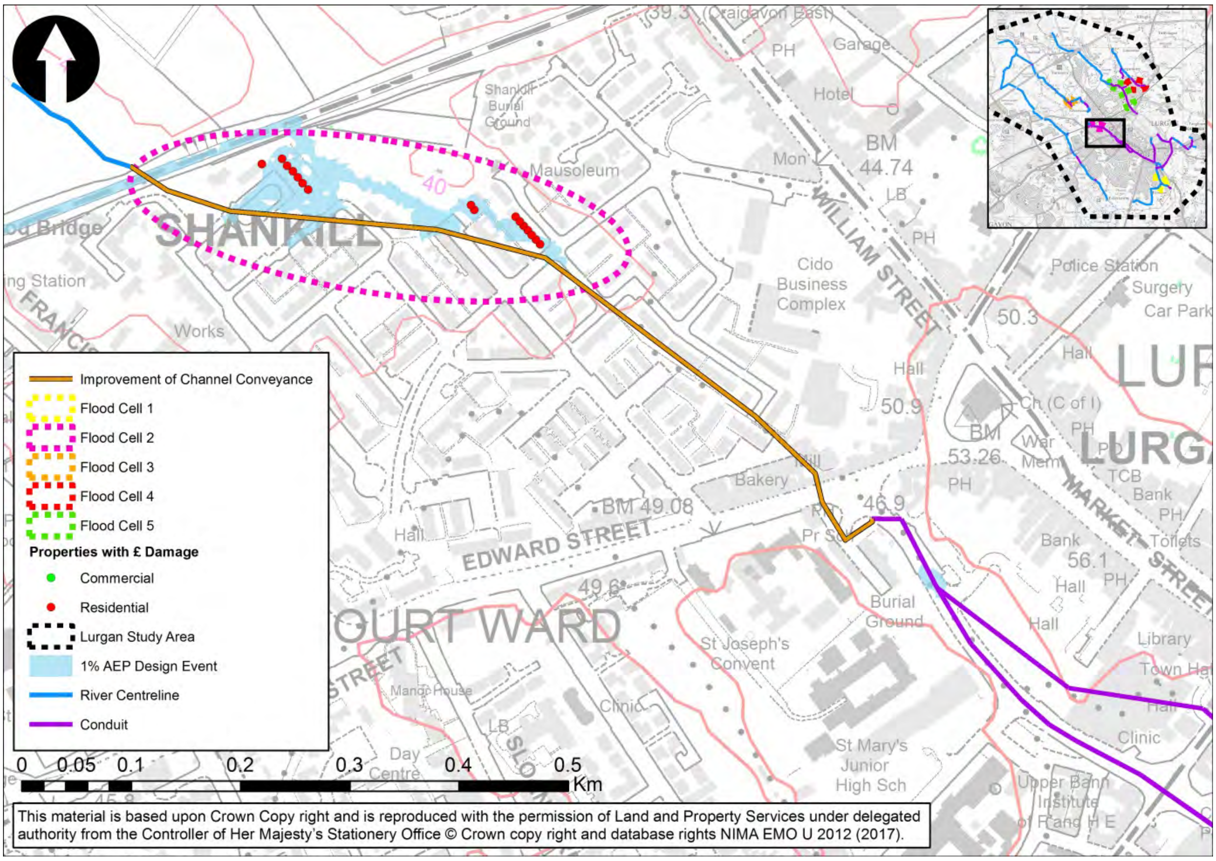

Figure 4.22 – Improvement of Channel Conveyance, Flood Cell 2

Flood Cell 3

There is potential for improvement of channel conveyance within flood cell 3. The flood cell is located at the upstream extent of a long culvert which is undersized to convey the 1% AEP event flow. Water levels rise upstream of the culvert and a single property is affected during the event. The existing culvert ranges in size from 900mm – 1300mm. A hydraulic model was constructed to simulate a culvert upgrade, the culvert as shown in Figure 4.23 was upgraded to a 1500mm pipe. Note however that the new pipe would be required to the laid deeper than the current pipe invert levels which would incur additional cost, some excavation would also be required downstream (land owned by Craigavon Golf Course) to achieve an acceptable gradient. Improvement of channel conveyance is a technically feasible measure for flood cell 3.

However the cost to implement this measure is approximately £137k, this is significantly more expensive than other technically viable measures for flood cell 3 and therefore this measure has been ruled out economically.

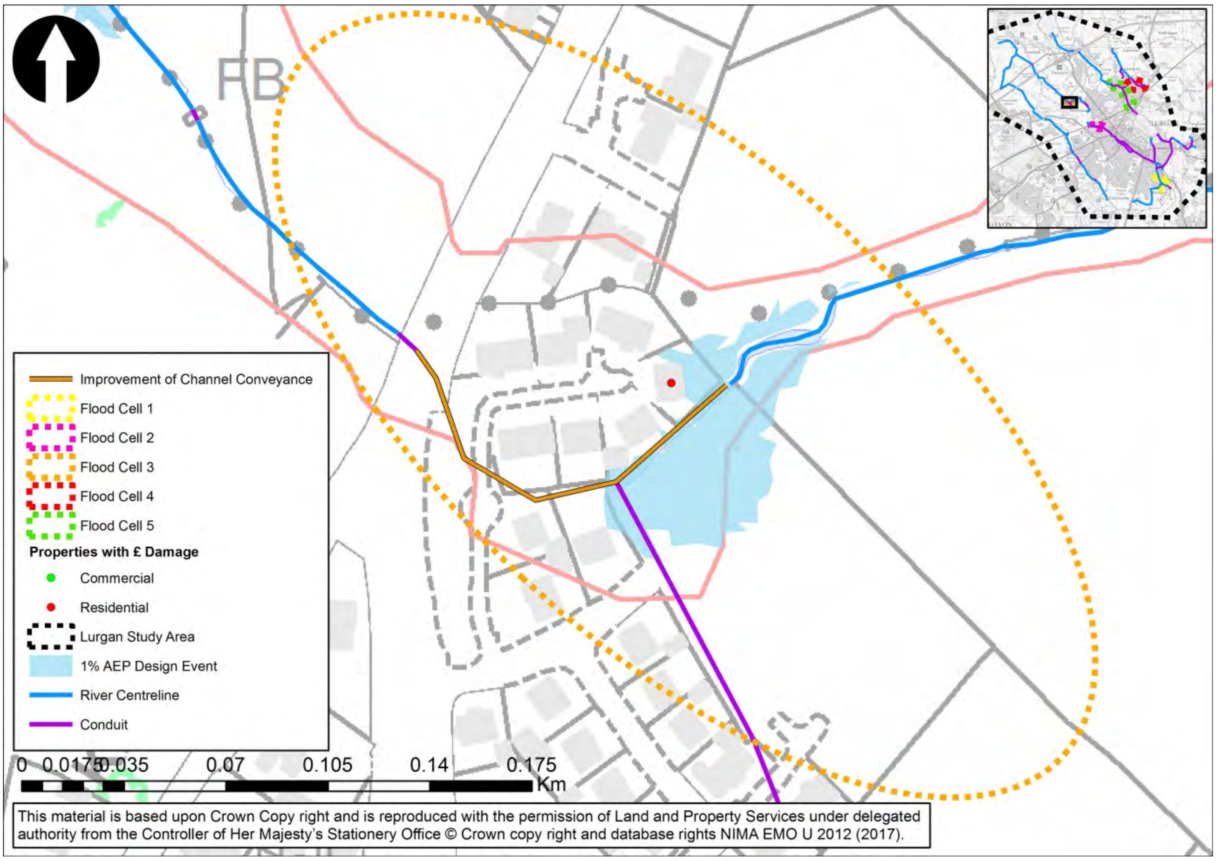

Figure 4.23 – Improvement of Channel Conveyance, Flood Cell 3

Flood Cell 4

There is potential for improvement of channel conveyance within flood cell 4. The flood cell is located along a long culvert which is undersized to convey the 1% AEP event flow. The existing culvert ranges in size from 440mm – 975mm. A hydraulic model was constructed to simulate the method, the location of the culvert upgrade is shown in Figure 4.24, its full length was upgraded to a 750mm pipe. No manholes surcharged during the simulation and all properties were shown to be protected. Therefore improvement of channel conveyance is a technically feasible measure for flood cell 4.

However the cost to implement this measure is approximately £172k, this is significantly more expensive than other technically viable measures for flood cell 4 and therefore this measure has been ruled out economically.

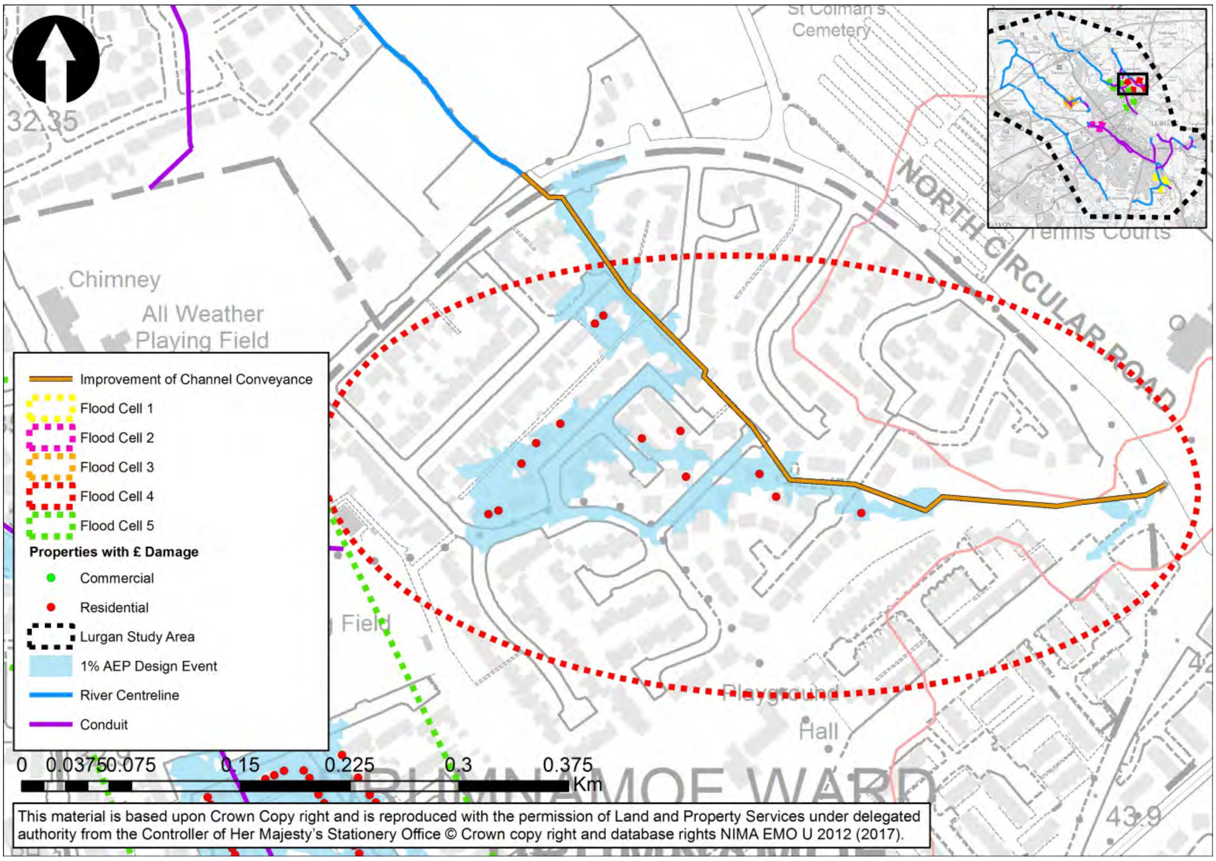

Figure 4.24 – Improvement of Channel Conveyance, Flood Cell 4

<u>Flood Cell 5</u>

There is potential for improvement of channel conveyance within flood cell 5. The flood cell is located along a long culvert which flows from Park Lake. The culvert is undersized to convey the 1% AEP event flow (culvert size ranges from 1070mm to 1380mm) and manholes surcharge creating overland flow paths which affect 134 properties. Figure 4.25 shows the extent of the culvert which would need to be upgraded. An initial hydraulic simulation was carried out with the culvert upgraded to a 1500mm pipe. As shown in Figure 4.27 the simulation was mostly successful however one manhole (U3902/04) surcharged and created an overland flow path affecting approximately 4 properties. Therefore this method is technically feasible and will protect the majority of properties but it would also require a single manhole to be sealed to fully protect all properties at risk.

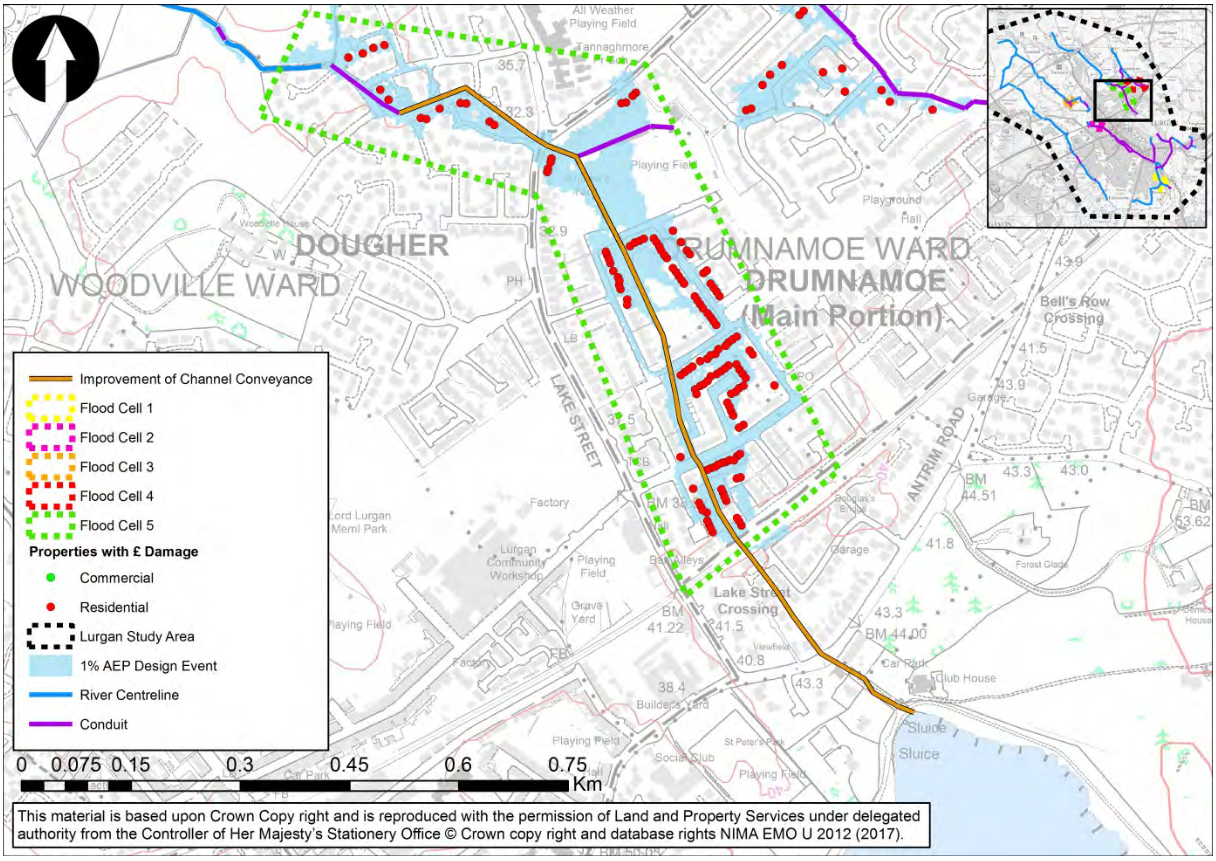

Figure 4.25 – Improvement of Channel Conveyance, Flood Cell 5

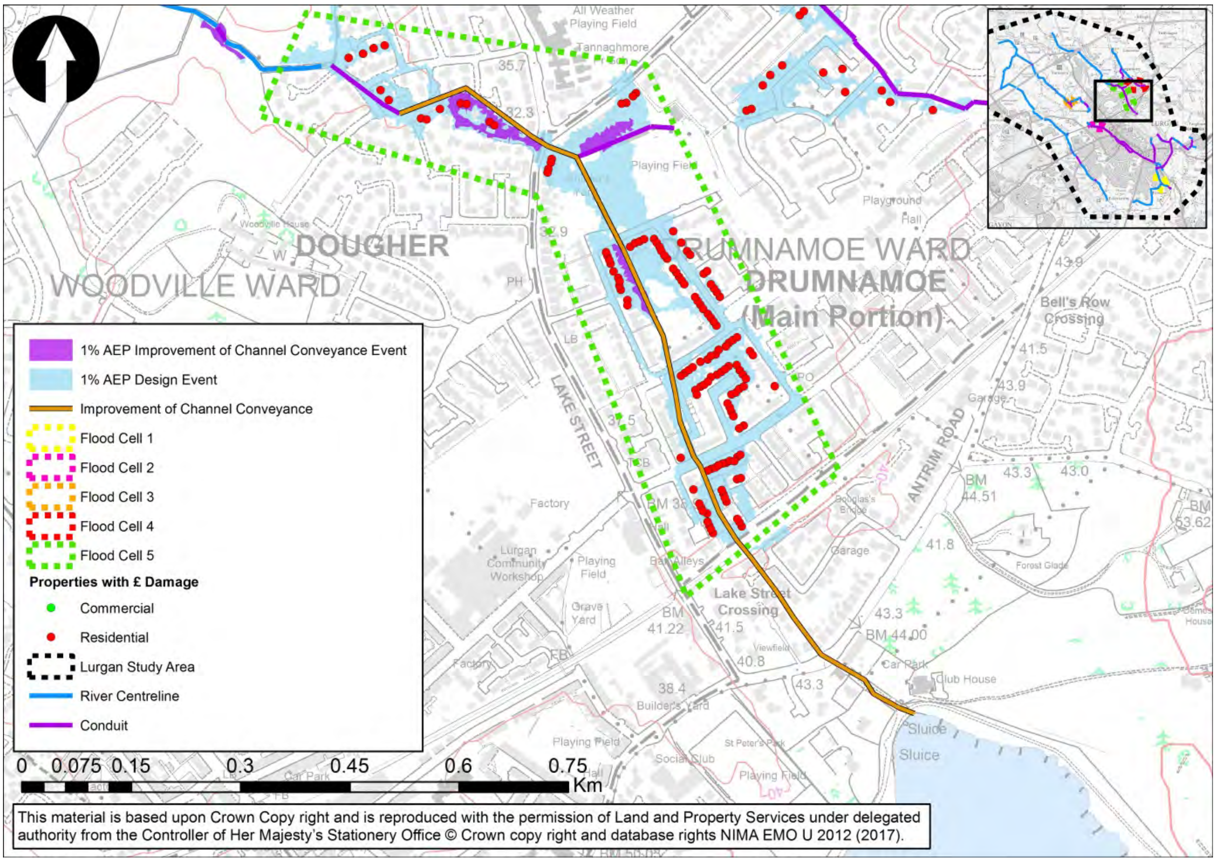

Figure 4.26 – Results of Improvement of Channel Conveyance, Flood Cell 5

A second hydraulic simulation was carried out increasing the culvert size downstream of the confluence with U3902BR to a 2100mm pipe. As shown in Figure 4.27 upgrading the culvert in two sections by different sizes will provide protection for all properties at risk within flood cell 5. However with this measure additional excavation would be required to place the culvert deeper into the ground.

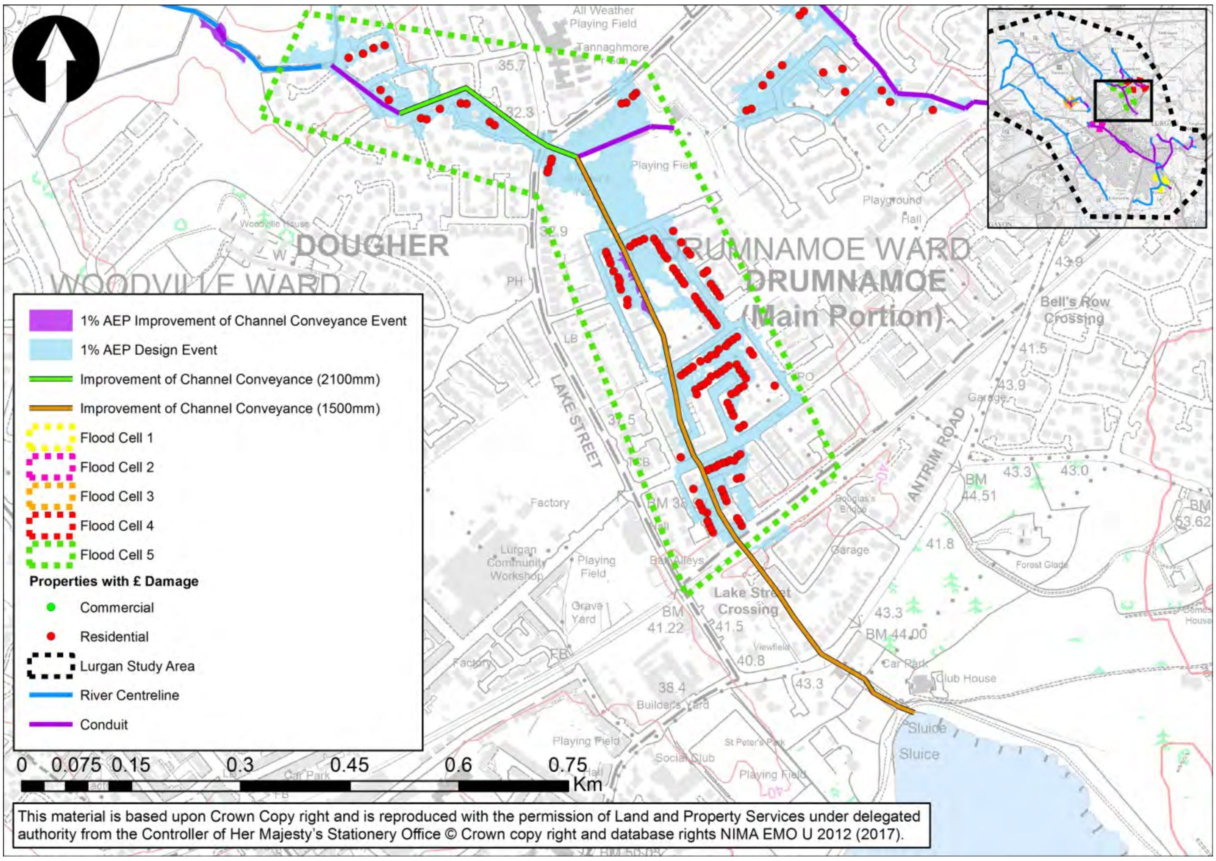

Figure 4.27 – Improvement of Channel Conveyance Version 2, Flood Cell 5

Improvement of channel conveyance is technically feasible however the cost to implement this measure is approximately £1.2m, this is significantly more expensive than other technically viable measures for flood cell 5 and therefore this measure has been ruled out economically.

4.1.2.7 Sealing Manholes

As Lurgan watercourses are heavily culverted there is potential to seal manholes which would protect properties at risk within flood cells 2, 4 and 5. This method of flood protection would not be applicable within flood cells 1 and 3 as the flooding mechanism is not surcharging manholes.

<u>Flood Cell 2</u>

Properties within flood cell 2 can be fully protected during the 1% AEP event if 4 manholes are sealed (locations of manholes are shown in Figure 4.28). In the current scenario these manholes surcharge causing overland flow paths which affect 16 properties. At this stage sealing manholes is a technically viable solution for flood risk within flood cell 2 however it should be noted that the condition of the culvert needs to be reviewed at detailed design stage. The estimated cost for the measure is approximately £38k.

Note, as the upstream storage measure has been screened in to provide benefit for flood cells 1 and 2 this measure could be screen out. However as there are unknown social implications associated with the upstream storage measure, sealing manholes (as the most economically advantageous measure) for flood cell 2 will also be put forward to manage flood risk in a separate option for the Lurgan Study Area.

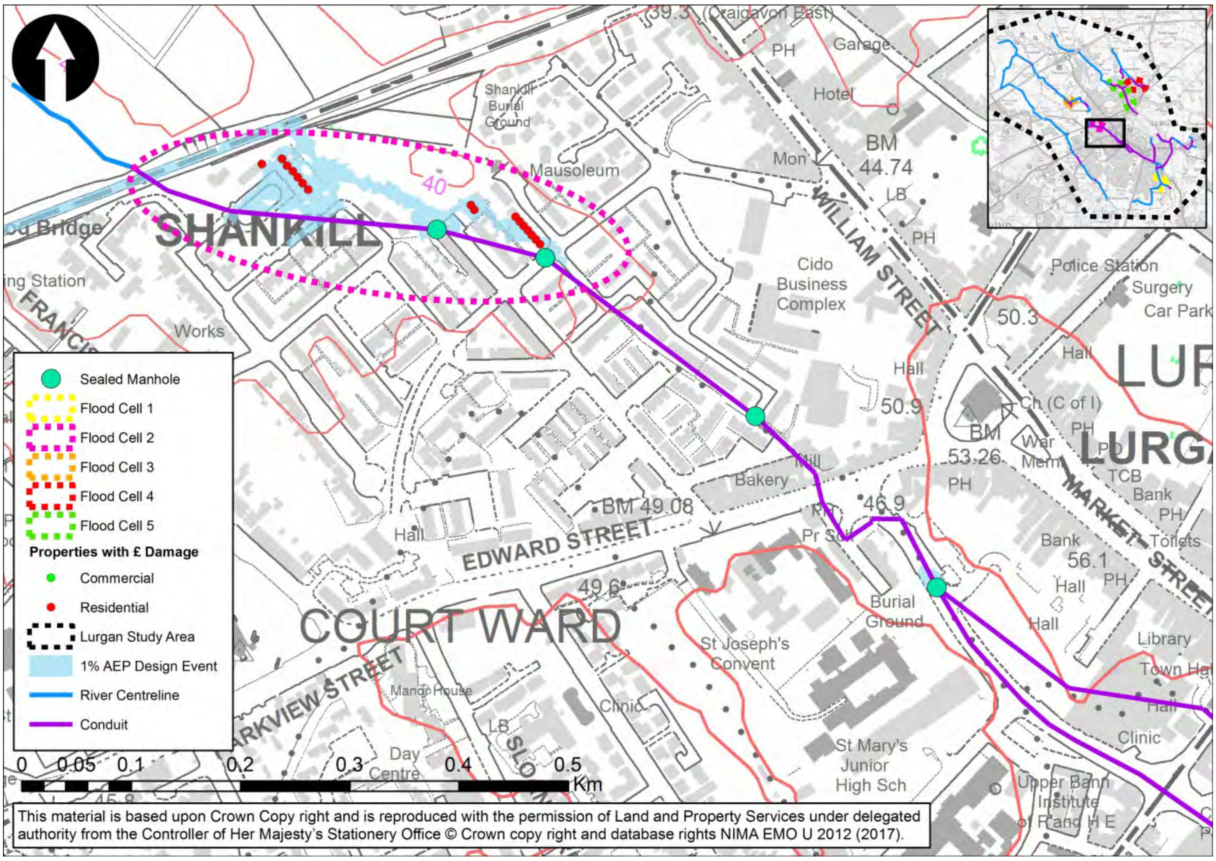

Figure 4.28 – Sealing Manholes, Flood Cell 2

Flood Cell 4

Properties within flood cell 4 can be fully protected during the 1% AEP event if 12 manholes are sealed (locations of manholes are shown in Figure 4.29). In the current scenario these manholes surcharge causing overland flow paths which affects 13 properties. At this stage sealing manholes is a technically viable solution for flood risk within flood cell 4 however it should be noted that the condition of the culvert needs to be reviewed at detailed design stage. The estimated cost for the measure is approximately £107.1k.

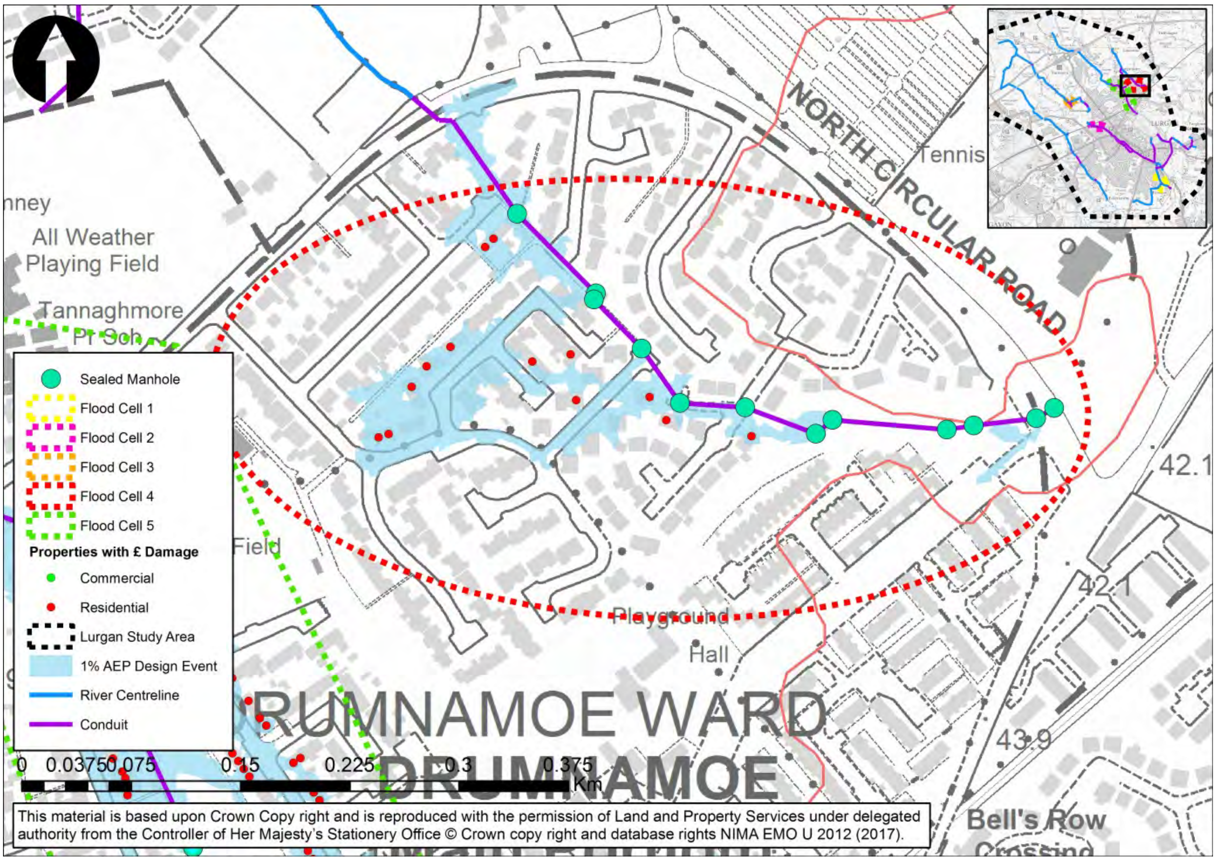

Figure 4.29 – Sealing Manholes, Flood Cell 4

Flood Cell 5

Properties within flood cell 5 can be fully protected during the 1% AEP event if 20 manholes are sealed (locations of manholes are shown in Figure 4.30). In the current scenario these manholes surcharge causing overland flow paths which affect 134 properties. At this stage sealing manholes is a technically viable solution for flood risk within flood cell 5 however it should be noted that the condition of the culvert needs to be reviewed at detailed design stage. The estimated cost for the measure is approximately £195.3k.

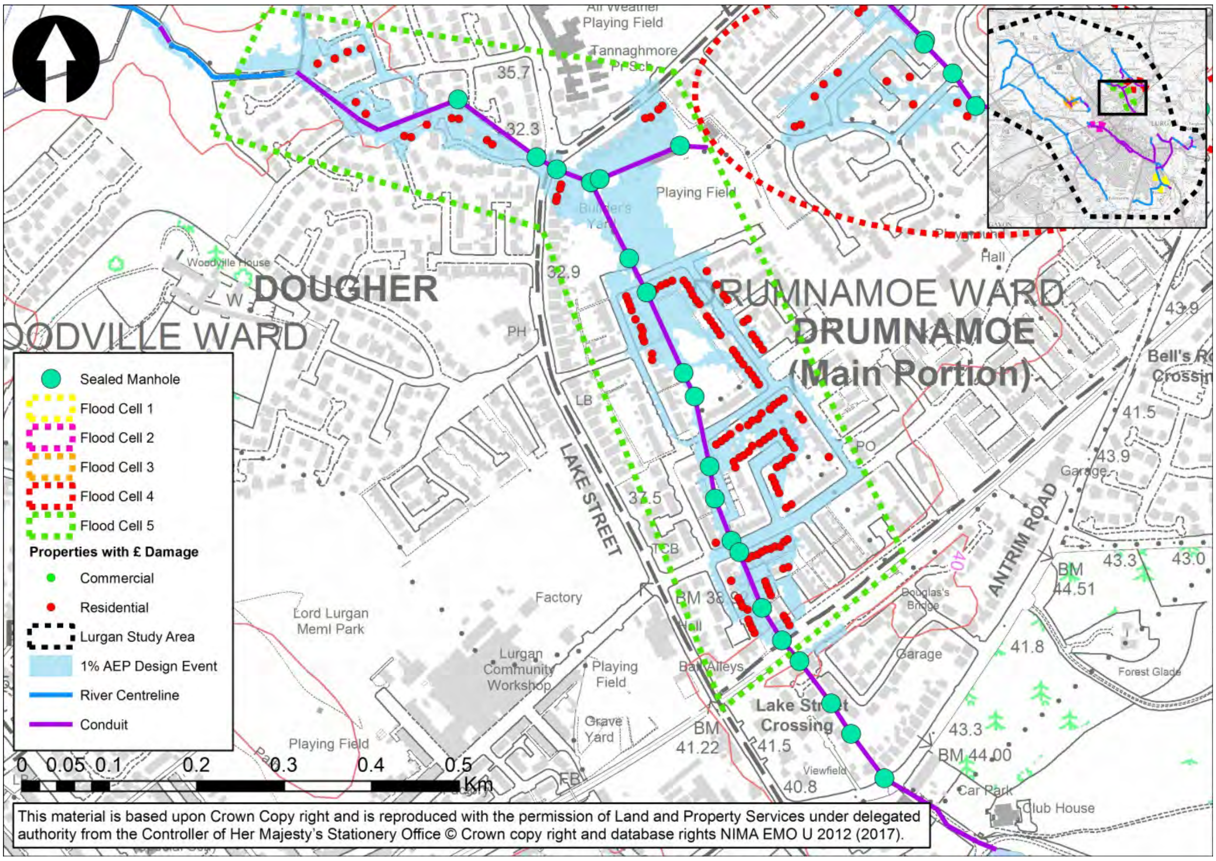

Figure 4.30 – Sealing Manholes, Flood Cell 5

4.1.2.8 Hard Defences

Hard Defences refer to physical barriers which prevent water from entering an area such as flood walls, embankments and barrages. As a general rule Hard Defences are kept as far back from the river channel or coast line as possible allowing the floodplain function to remain active. Where this is not possible, due to flood risk receptors being located within the floodplain, Hard Defences are placed around the property boundary to afford it protection. Where space allows flood embankments are used but where space is restricted flood walls are utilised.

A review was carried out for each flood cell to ascertain where hard defences would be required to protect properties at risk during a 1% AEP flood event. The flooding mechanism within flood cells 4 and 5 are overland flow paths from surcharging manholes. During an event water spills from manholes in various directions and flows along roads and in between properties. Due to the nature of the overland flow paths locations for hard defences could not be determined. Hard defences are not a technically viable measure for protection within flood cells 4 and 5.

Flood Cell 1

A review was carried out for flood cell 1 to ascertain where hard defences would be required to protect properties at risk during a 1% AEP flood event. To determine the effectiveness of the hard defences, a hydraulic model was constructed to simulate the method of protection. The locations of the hard defences required to protect the 4 properties within flood cell 1 are shown in Figure 4.31 below. The model showed that the hard defences with a total length of approximately 570m and average height of approximately 0.9m would protect all receptors in the 1% AEP event. The estimated cost for the measure is approximately £235.1k, this is similar to the cost of the upstream storage measure. As there are unknown social implications associated with the upstream storage measure and costs of the measures are similar, hard defences for flood cell 1 will also be put forward to manage flood risk in a separate option for the Lurgan Study Area.

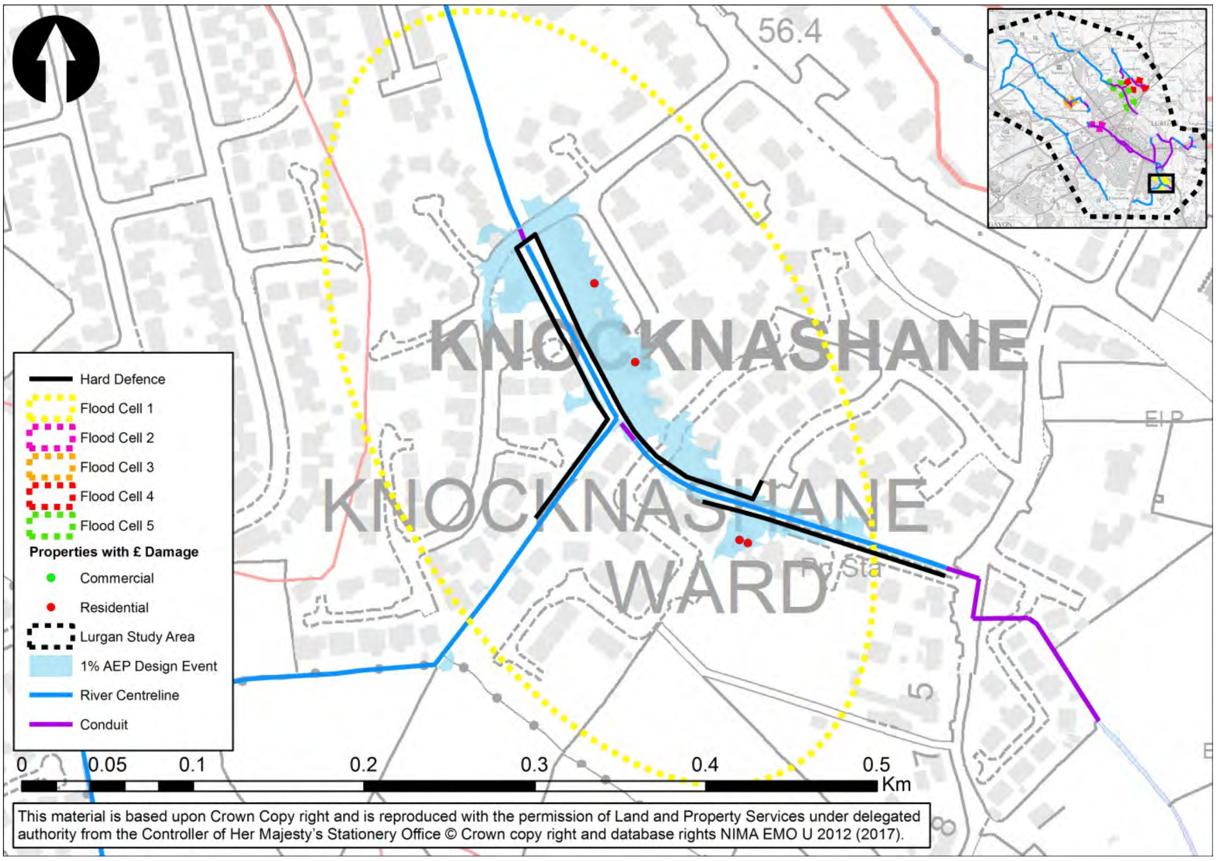

Figure 4.31 – Hard Defences, Flood Cell 1

Flood Cell 2

A review was carried out for flood cell 2 to ascertain where hard defences would be required to protect properties at risk during a 1% AEP flood event. To determine the effectiveness of the hard defences, a hydraulic model was constructed to simulate the method of protection. The flooding mechanism within flood cell 2 is overland flow paths from surcharging manholes, hard defences were placed to divert flow paths away from properties. The locations of the hard defences required to protect the 16 properties within flood cell 2 are shown in Figure 4.32 below. The model showed that the hard defences with a total length of approximately 170m and average height of approximately 0.7m would protect all receptors in the 1% AEP event.

The estimated cost for the measure is approximately £56.2k, this is more expensive than other technically viable measures screened for flood cell 2. In addition the hard defences are positioned to simply divert overland flow paths away from properties leaving flood waters on roads and open areas rather than containing flood waters within a channel or specific area. As the risk is simply being moved from property to other receptors and the measure is more expensive it has been ruled out of the screening process.

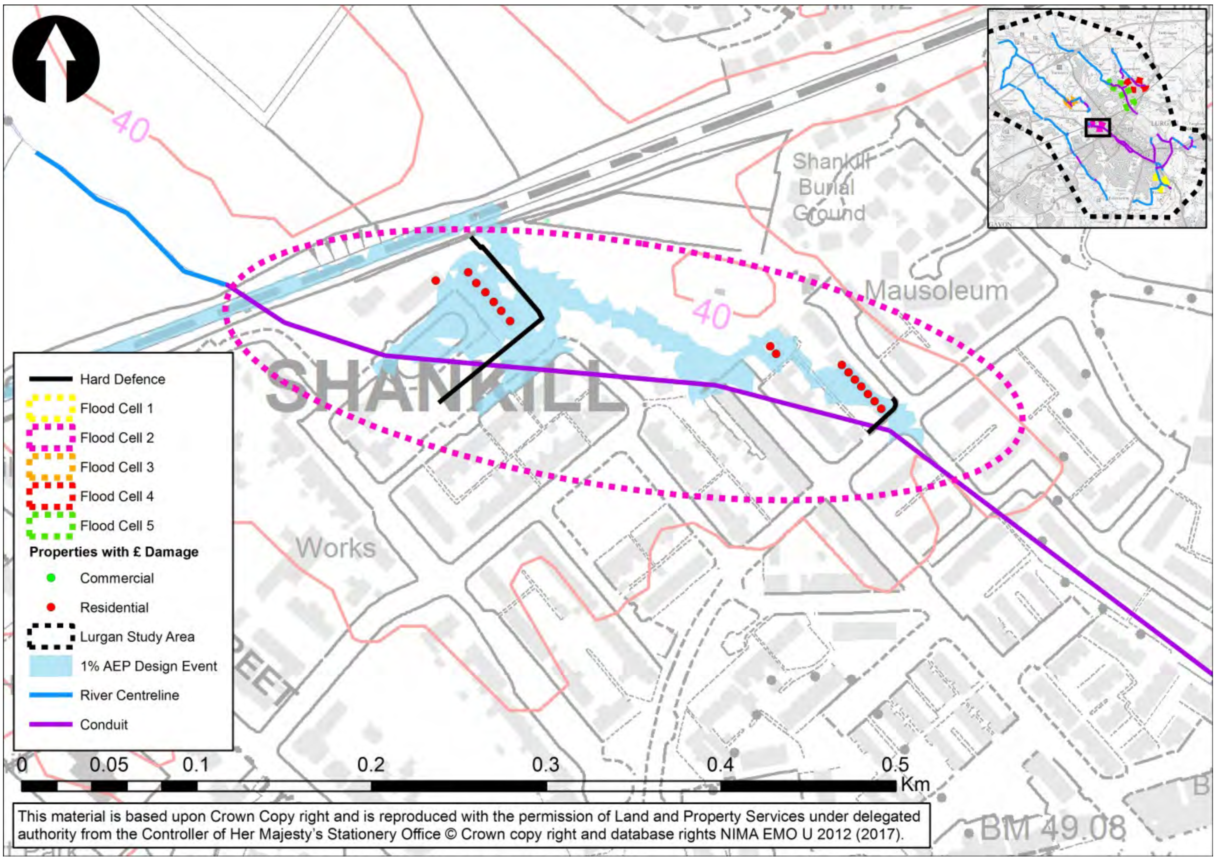

Figure 4.32 – Hard Defences, Flood Cell 2

<u>Flood Cell 3</u>

A review was carried out for flood cell 3 to ascertain where hard defences would be required to protect the single property which is at risk during a 1% AEP flood event. To determine the effectiveness of the hard defences, a hydraulic model was constructed to simulate the method of protection. A small extent of wall is required along the perimeter of the rear garden to provide protection, the location of the hard defences is shown in Figure 4.33 below.

The model showed that the hard defences with a total length of approximately 40m and average height of approximately 0.6m would protect all receptors in the 1% AEP event. The estimated cost for the measure is approximately £12.5k, this is significantly less expensive than other technically viable measures and therefore hard defences will be brought forward as the preferred measure for flood cell 3 to complete an option for the Lurgan Study Area.

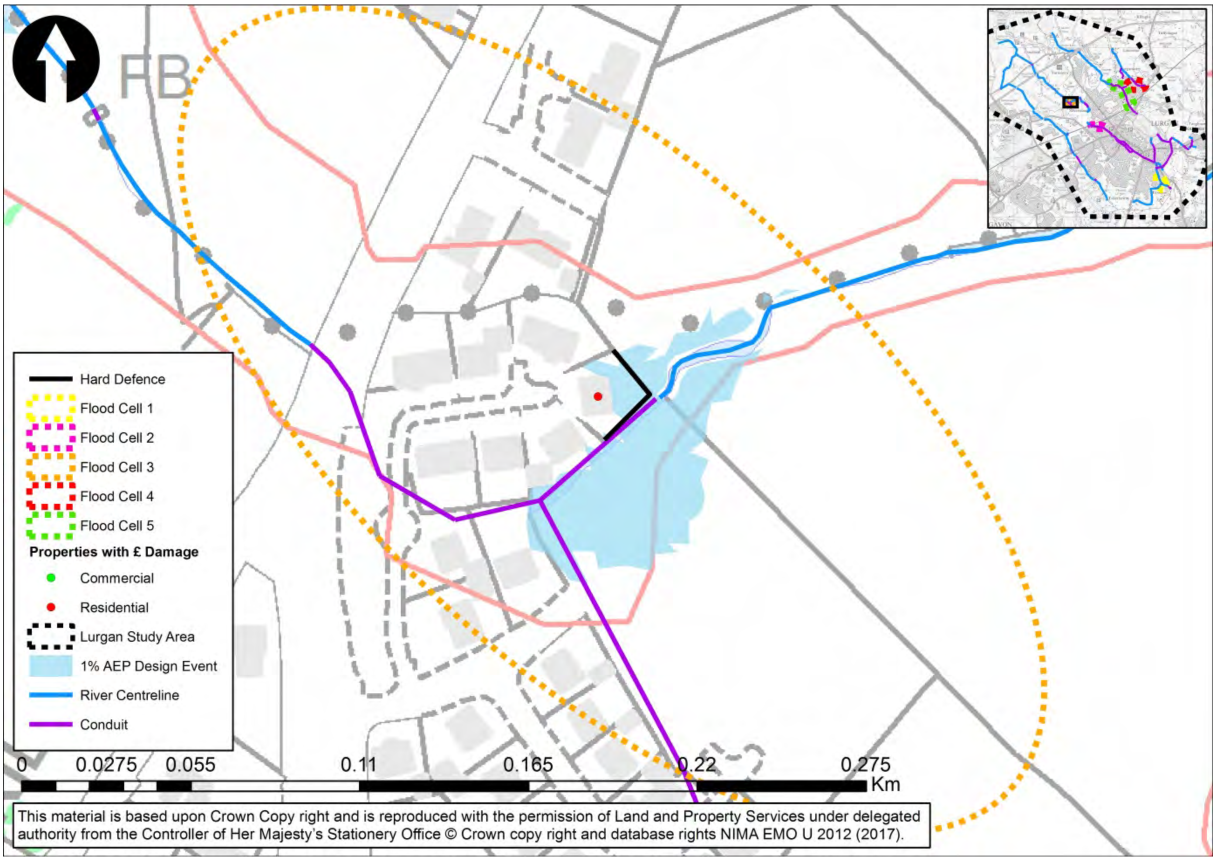

Figure 4.33 – Hard Defences, Flood Cell 3

4.1.2.9 Relocation of Properties

To relocate a property is to abandon the existing at risk property and provide an alternative in a location not at risk. While this method is, in theory, possible, it is not practical for a whole town of many at risk properties. Its use is more applicable for discrete areas where single properties or clusters of properties are located.

<u>Flood Cell 1</u>

There are 4 properties at risk within Flood Cell 1 which may be considered for relocation. It was estimated that the cost to relocate these properties would be £471k. Upon economic review it was found that other technically viable measures to protect the properties at risk, cost less, are more economically viable and socially acceptable. Therefore while it would be technically feasible to relocate the properties this measure has been screened out of the process.

<u>Flood Cells 2</u>

There are 16 properties at risk in the 1% AEP event in Flood Cell 2. The cost associated with relocating these properties was estimated to be £1.88m. This measure accounts for a significant portion of the £2.59 million benefit available to compare scheme costs to. Upon economic review it was found that other technically viable measures to protect the properties at risk, cost less, are more economically viable and socially acceptable. Therefore while it would be technically feasible to relocate these properties this measure is deemed economically unviable.

Flood Cell 3

In flood cell 3 there is an individual property identified at risk; the cost associated with relocation of this property is considered to be £118k. However upon economic review it was found that other technically viable measures to protect the property at risk, cost less, are more economically viable and socially acceptable. Therefore while it would be technically feasible to relocate the property this measure is deemed economically unviable.

Flood Cell 4

Flood cell 4 contains 13 properties at risk in the 1% AEP event; these are scattered throughout a large residential development. The cost associated with relocation of these properties is considered to be £1.53m. However upon economic review it was found that other technically viable measures to protect the properties at risk, cost less and are more economically viable. Therefore while it would be technically feasible to relocate the properties this measure is deemed economically unviable. In addition relocation in this area is not considered a socially acceptable solution due to the extent of flooding which results in at risk properties being scattered throughout a larger housing estate.

Flood Cell 5

This method was considered socially unacceptable for flooding in Flood Cell 5 due to the large number of properties which would need to be relocated (134) and therefore the scale of disruption it would cause to residents. This method would also be economically unviable as the total cost to relocate all properties at risk is approximately £15.76m compared to the damages incurred by these properties during a 1% AEP event of £2.59m.

4.1.2.10 Diversion of Flow

This method involves directing some of the floodwater via a new route thereby reducing flow and associated flood risk along the original route. The new flow route would normally consist of a constructed open channel and/or culvert system or an existing linear feature able to convey the flow to a designated discharge point.

This method was considered technically unfeasible for flood cell 1 and 5. The surrounding topography was reviewed however no flow diversion routes were identified which could benefit the properties at risk during the 1% AEP event.

Flood Cell 2

A flow diversion route was identified to benefit at risk properties within flood cell 2. A new culvert could be constructed between manholes MH507 and MH489, as shown in Figure 4.34. A hydraulic model was constructed to simulate the flow diversion which showed flow being taken away from the main system and therefore preventing manholes from surcharging and protecting all properties during a 1% AEP event. The new 600mm diameter culvert would extend approximately 550m along Prospect Way, Oakfield Terrace, Silverwood Drive and Cypress Gardens before re-joining the open watercourse.

However the cost to implement this measure is approximately £270.3k, this is significantly more expensive than other technically viable measures for flood cell 2 and therefore this measure has been ruled out economically.

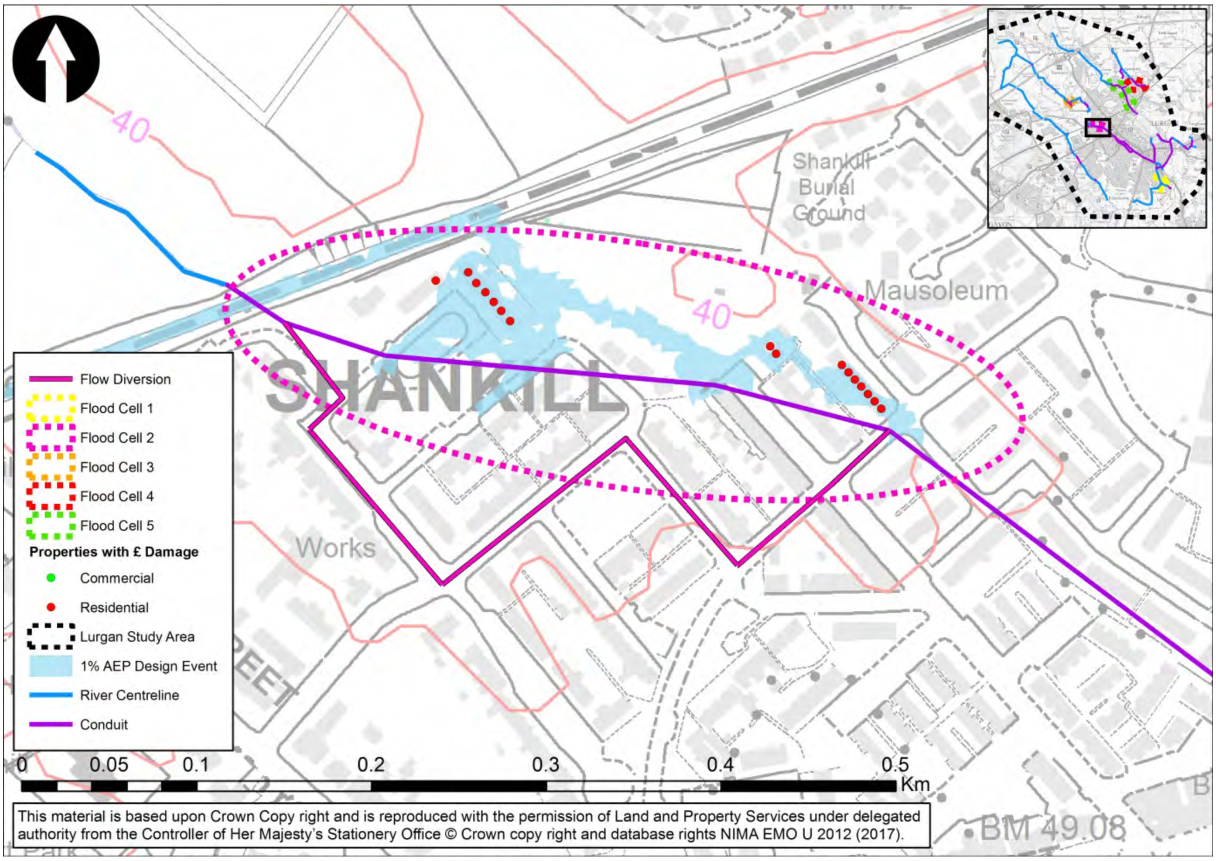

Figure 4.34 – Diversion of Flow, Flood Cell 2

<u>Flood Cell 3</u>

The surrounding topography was reviewed and one flow diversion route was identified which could potentially benefit the property at risk within flood cell 3 during the 1% AEP event (as shown in Figure 4.35). However this method is technically complex and would be expensive compared to other measures which have already been identified. Therefore it is recommended that flow diversion is only considered for flood cell 3 if other measures are found to be unfeasible later in the process.

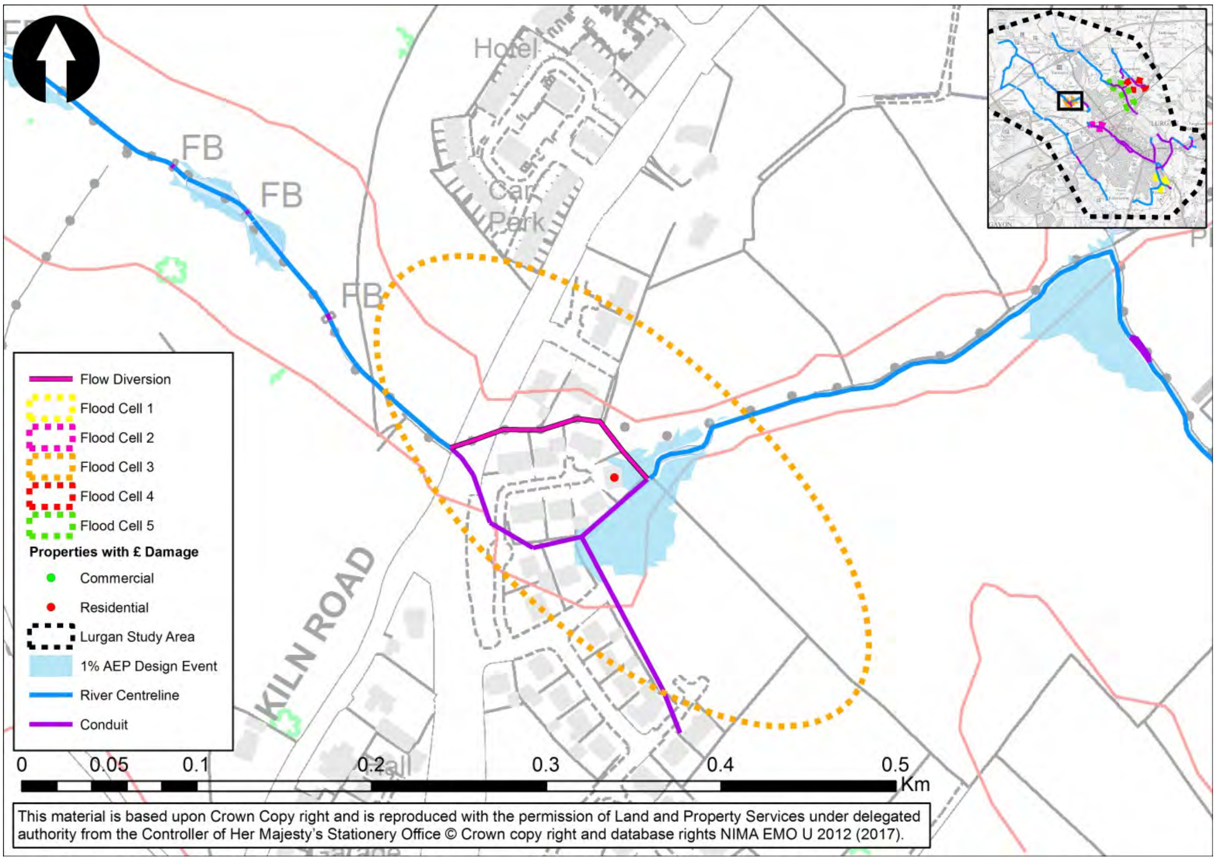

Figure 4.35 – Diversion of Flow, Flood Cell 3

Flood Cell 4

A flow diversion route was identified to benefit at risk properties within flood cell 4. A new culvert could be constructed between manholes SJ08598803 and SJ08604001, as shown in Figure 4.36. A hydraulic model was constructed to simulate the flow diversion which showed the new culvert would need to take the majority of flow, leaving the original culvert to only take the lateral flow over its length. This prevents manholes from surcharging and protects all properties at risk during the 1% AEP event. The new culvert, a 675mm pipe would extend approximately 520m along North Circular Road. Note however that there is a high point along the topography of the North Circular Road which would cause complications during the construction of the diversion (as shown in Figure 4.37).

However the cost to implement this measure is approximately £394k, this is significantly more expensive than other technically viable measures for flood cell 4 and therefore this measure has been ruled out economically.

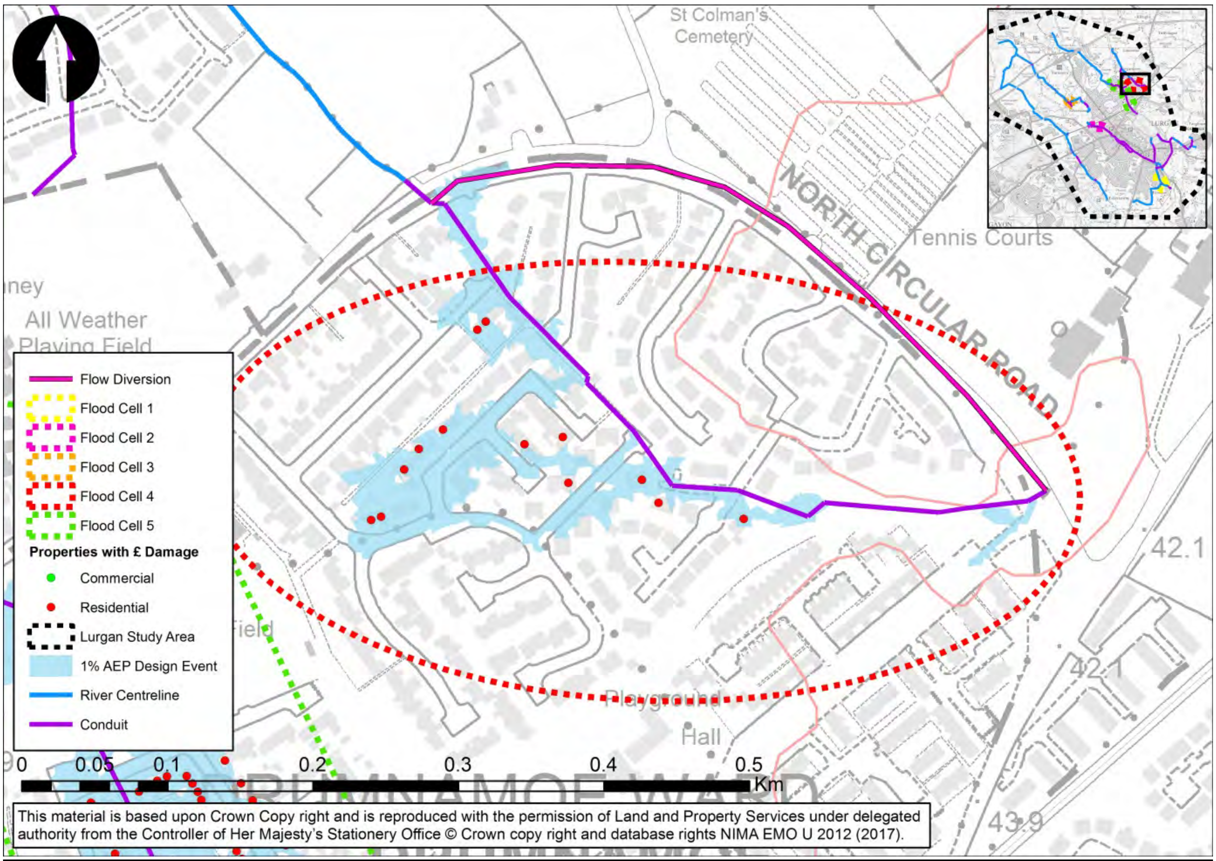

Figure 4.36 – Diversion of Flow, Flood Cell 4

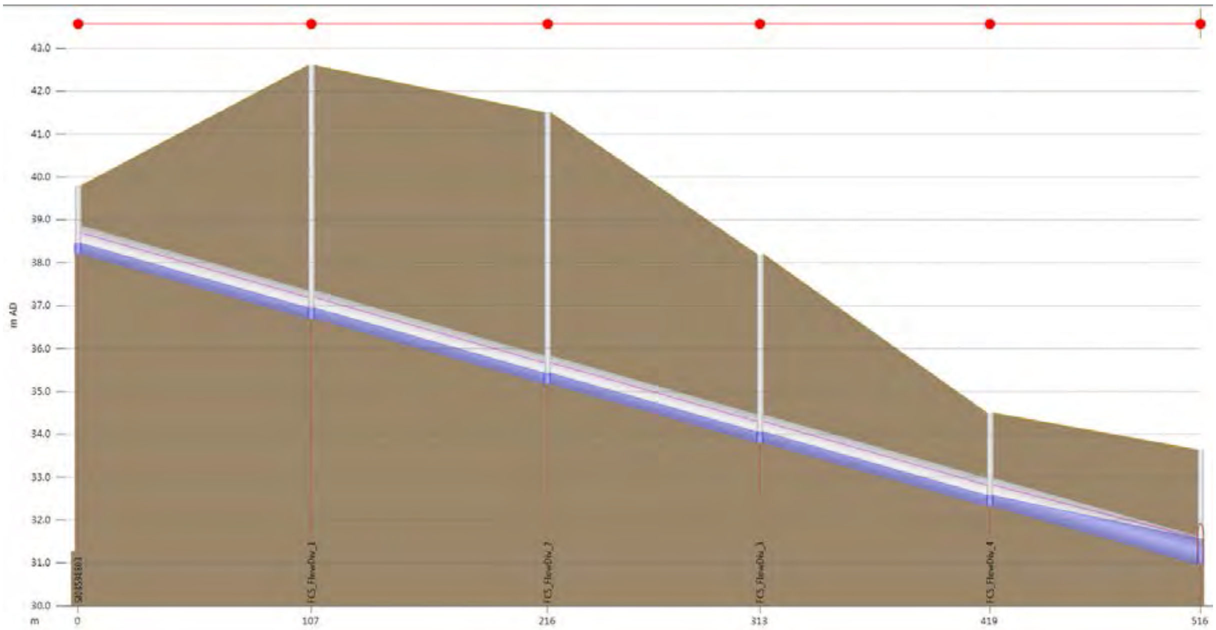

Figure 4.37 – Diversion of Flow, Long Section, Flood Cell 4

4.1.2.11 Flood Warning/ Forecasting

For a flood warning/forecasting system to be effective there needs to be adequate warning time for appropriate action to be taken. As the flood risk in Lurgan is associated with smaller watercourses which have a flashy response time, there would not be adequate flood warning time to allow a forecasting system to be effective.

4.1.2.12 Public Awareness Campaign

A public awareness campaign would be useful in Lurgan to alert residents and business owners to the types and sources of flooding in their area. This would allow individuals to take informed actions to help prevent their property from flooding.

4.1.2.13 Individual Property Protection

Individual property protection could consist of flood gates and vent seals on the building structure itself. Where flood depths are over 0.6m this method becomes unfeasible and flood resilience techniques would be recommended over flood gates. As this method is temporary and relies on human intervention there is an element of uncertainty as to whether the full SoP will be met for every flood event. As such it is assumed that 20% of the flood damage will be avoided.

Individual property protection may be suitable for all the properties located within flood cells 1, 2, 3, 4 & 5 as the flood depths are less than 0.6m. However as the depths are low, sandbags may also be effective and so temporary defences may be a more economically viable option.

4.1.2.14 Other Works

No other works have been identified to benefit flood risk within Lurgan.

4.2 DEVELOPMENT OF OPTIONS

In Lurgan, five independent locations have been reviewed each with different flooding mechanisms. Properties are at risk within flood cell 1 due to insufficient channel capacity and out of bank flooding, whereas the flooding mechanism within flood cells 2, 4 and 5 is due to insufficient capacity within the culvert systems resulting in manholes surcharging. The flood risk within flood cell 3 has been identified as insufficient culvert capacity resulting in out of bank flooding from the open channel upstream of the culvert inlet. In order to develop options each flooding mechanism was considered separately during the screening of methods and the results are shown below. Two types of options have been considered, short-term solutions or “quick-wins” and long-term solutions. The “quick-win” options may not provide the full SoP but aim to reduce the flood risk in the interim period before a long-term solution can be implemented. Interim methods are discussed in Section 4.6. Long-term solutions should provide the design SoP (1% AEP event).

4.2.1 Suitable methods for the Knocknashane (Flood Cell 1)

Method	Screening	Explanation
Do nothing	✗	Technically unfeasible
Additional Maintenance	✗	Technically unfeasible
Temporary Defences	✓	Short term solution
Planning and Development Control	✗	Technically unfeasible
Land Use Management	✗	Technically unfeasible
Upstream Storage	✓	Long term solution
Improvement of Channel Conveyance	✗	Technically unfeasible
Sealing Manholes	✗	N/A
Hard Defences	✓	Long term solution
Relocation of Properties	✗	Economically unviable
Diversion of Flow	✗	Technically unfeasible
Flood Warning/Forecasting	✗	Technically unfeasible
Public Awareness Campaign	✓	Short term solution
Individual Property Protection	✓	Short term solution
Other Works	✗	N/A

The following long-term methods have been carried forward to address the flood risk arising in flood cell 1:

- Upstream Storage
- Hard Defences

The following short-term methods have been carried forward to address the flood risk arising in flood cell 1:

- Temporary Defences
- Public Awareness Campaign
- Individual Property Protection

4.2.2 Suitable methods for the Shankill (Flood Cell 2)

Method	Screening	Explanation
Do nothing	✗	Technically unfeasible
Additional Maintenance	✗	Technically unfeasible
Temporary Defences	✗	Technically unfeasible
Planning and Development Control	✗	Technically unfeasible
Land Use Management	✗	Technically unfeasible
Upstream Storage	✓	Long term solution
Improvement of Channel Conveyance	✗	Economically unviable
Sealing Manholes	✓	Long term solution
Hard Defences	✗	Economically unviable
Relocation of Properties	✗	Economically unviable
Diversion of Flow	✗	Economically unviable
Flood Warning/Forecasting	✗	Technically unfeasible
Public Awareness Campaign	✓	Short term solution
Individual Property Protection	✓	Short term solution
Other Works	✗	N/A

The following long-term methods have been carried forward to address the flood risk arising from flood cell 2:

- Upstream Storage
- Sealing Manholes

The following short-term methods have been carried forward to address the flood risk arising from flood cell 2:

- Public Awareness Campaign
- Individual Property Protection

4.2.3 Suitable methods for the Kiln Lodge (Flood Cell 3)

Method	Screening	Explanation
Do nothing	×	Technically unfeasible
Additional Maintenance	×	Technically unfeasible
Temporary Defences	✓	Short term solution
Planning and Development Control	×	Technically unfeasible
Land Use Management	×	Technically unfeasible
Upstream Storage	×	Economically unviable
Improvement of Channel Conveyance	×	Economically unviable
Sealing Manholes	×	N/A
Hard Defences	✓	Long term solution
Relocation of Properties	×	Economically unviable
Diversion of Flow	×	Technically complex
Flood Warning/Forecasting	×	Technically unfeasible
Public Awareness Campaign	✓	Short term solution
Individual Property Protection	✓	Technically feasible
Other Works	×	N/A

The following long-term methods have been carried forward to address the flood risk arising from flood cell 3:

- Hard Defences

The following short-term methods have been carried forward to address the flood risk arising from flood cell 3

- Temporary Defences
- Public Awareness Campaign
- Individual Property Protection

4.2.4 Suitable methods for the North Circular Road (Flood Cell 4)

Method	**Screening**	**Explanation**
Do nothing	✗	Technically unfeasible
Additional Maintenance	✗	Technically unfeasible
Temporary Defences	✗	Technically unfeasible
Planning and Development Control	✗	Technically unfeasible
Land Use Management	✓	Long term solution
Upstream Storage	✗	Technically unfeasible
Improvement of Channel Conveyance	✗	Economically unviable
Sealing Manholes	✓	Long term solution
Hard Defences	✗	Technically unfeasible
Relocation of Properties	✗	Economically unviable
Diversion of Flow	✗	Economically unviable
Flood Warning/Forecasting	✗	Technically unfeasible
Public Awareness Campaign	✓	Short term solution
Individual Property Protection	✓	Short term solution
Other Works	✗	N/A

The following long-term methods have been carried forward to address the flood risk arising from flood cell 4:

- Land Use Management
- Sealing Manholes

The following short-term methods have been carried forward to address the flood risk arising from flood cell 4:

- Public Awareness Campaign
- Individual Property Protection

4.2.5 Suitable methods for the Drumnamoe (Flood Cell 5)

Method	Screening	Explanation
Do nothing	✗	Technically unfeasible
Additional Maintenance	✗	Technically unfeasible
Temporary Defences	✓	Short term solution
Planning and Development Control	✗	Technically unfeasible
Land Use Management	✓	Long term solution
Upstream Storage	✗	Technically unfeasible
Improvement of Channel Conveyance	✗	Economically unviable
Sealing Manholes	✓	Long term solution
Hard Defences	✗	Technically unfeasible
Relocation of Properties	✗	Economically unviable
Diversion of Flow	✗	Technically unfeasible
Flood Warning/Forecasting	✗	Technically unfeasible
Public Awareness Campaign	✓	Short term solution
Individual Property Protection	✓	Short term solution
Other Works	✗	N/A

The following long-term methods have been carried forward to address the flood risk arising from flood cell 5:

- Land Use Management
- Sealing Manholes

The following short-term methods have been carried forward to address the flood risk arising from flood cell 5:

- Temporary Defences
- Public Awareness Campaign
- Individual Property Protection

4.2.6 Potential Options

A review of the screened methods was carried out in order to develop potential long-term options. In Flood Cell 1 upstream storage or hard defences will provide the design SoP, for Flood Cell 2 upstream storage or sealing manholes will provide the design SoP. For Flood Cell 3 the only long-term method identified was Hard Defences. For flood cells 4 and 5 the only long-term method identified was sealing manholes.

Flood Warning / Forecasting, while technically feasible, could only be utilised as part of an option if a warning was required to put defences in place. If flood gates or demountable defences are required as part of the preferred option then Flood Warning/Forecasting should be included.

Three potential options have therefore been identified and summarised below.

Option 1:

- Maintain Existing Regime (Baseline Scenario)

Option 2:

- Upstream Storage
- Hard Defences
- Sealing Manholes

Option 3:

- Hard Defences
- Sealing Manholes

4.3 APPRAISAL OF OPTIONS

Table 4.3 below provides a qualitative assessment of the anticipated performance of each option considering the relevant objectives and constraints. [✓ to ✓✓✓] represents a moderately good to very good performance. [-] represent a neutral outcome. [× to ×××] represents a moderately negative to very negative performance.

Table 4.3 - Qualitative assessment of options for Lurgan

Objectives/Constraints	Option 1	Option 2	Option 3
Provide design SoP to all properties	×××	✓✓✓	✓✓✓
Complexity of option	-	××	×
Impact to road drainage	-	×	××
No increase in flood risk to other receptors	-	✓	×
Adaptability to climate change	-	✓	××
Health and Safety issues	-	×	×
Impact to residential areas	-	××	×
Impact to private land owners	-	××	×
Impact to socially important receptors	-	-	-
Impact to ASSI, SPA, RAMSAR & Ancient Woodland	-	-	-
Reduced risk to roads	-	✓✓	✓
Value for money	-	✓✓	✓

The qualitative assessment shows that both Option 2 and 3 would produce a significant improvement to the flood risk in Lurgan compared to the baseline Option 1. Both Option 2 and 3 would provide the design SoP to a 1% AEP flood event.

The remainder of the qualitative assessment compares Option 2 and 3 in order to identify the preferred option. Option 2 has been marked down on complexity of the option, whilst option 3 has a greater impact on road drainage. Option 2 would not increase flood risk to other receptors as water would be held upstream of some receptors. Additionally it is anticipated that Option 2 would be more adaptable to climate change as the storage area identified would have additional storage capacity.

Both options will have their inherent health and safety issues. Both options consist of a series of hard defences, heights of up to 0.8m for option 2 and up to 1.4m for option 3.

As many of the measures are located in residential areas, there may be significant disruption to residents during construction.

The cost was estimated for both Option 2 and 3. Option 2 was estimated to cost £979,685 whilst Option 3 was estimated to cost £1,036,189. Therefore Option 2 offers better value for money.

4.3.1.1 Review of Options

The following section details design issues or health and safety issues that were identified during the optioneering process. The placement of hard defences throughout Lurgan was considered carefully so as no new problems would be created.

There has been development in the area of Flood Cell 1 since the model build - Bowens Meadow has been expanded and new road layouts in this location may not be fully represented in the model. Option 3 proposes hard defences in this area however the proposed layout may not work with newly constructed roads. The proposed hard defences currently cut across a road as shown in Figure 4.38 below. The hard defences could be tied into high ground or linked to the head walls of the road bridge structure.

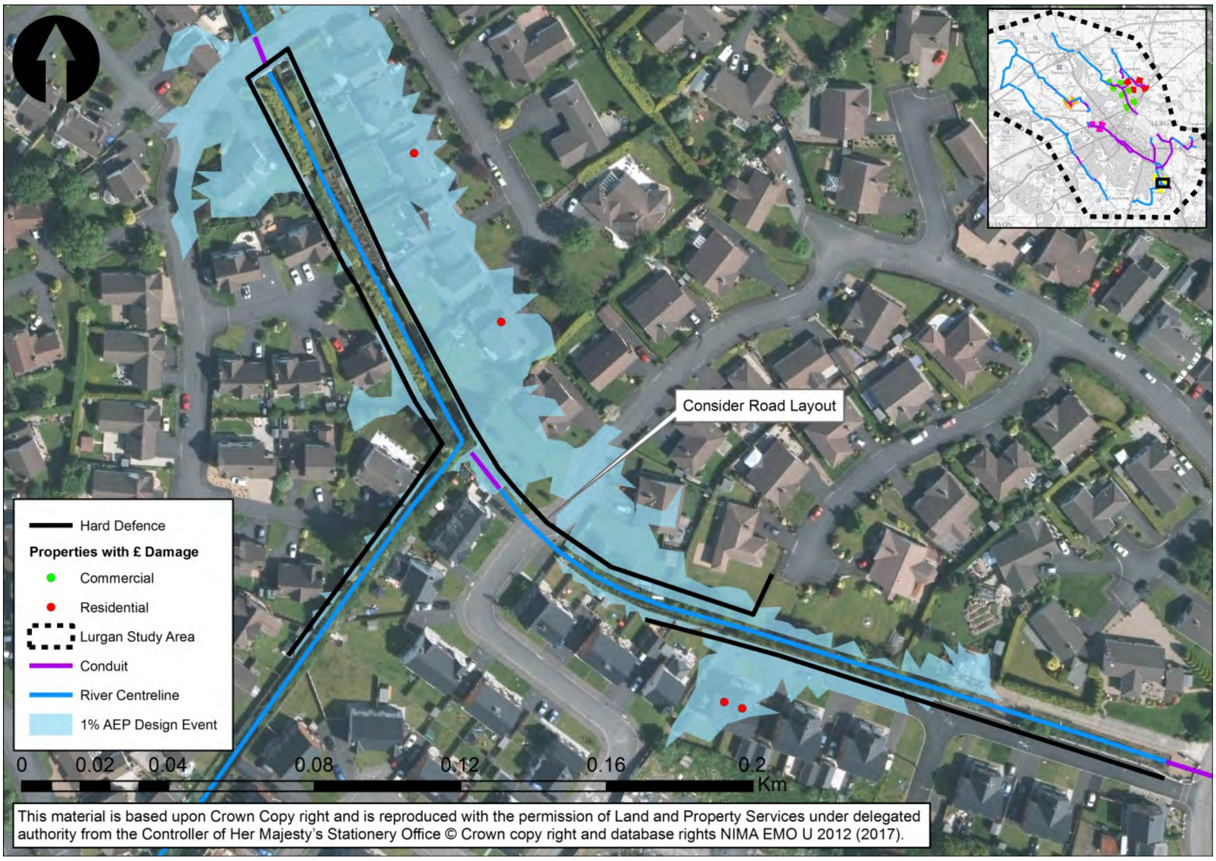

Figure 4.38 – Flood Cell 1 Proposed Hard Defences

Another constraint with both options could be the sealing of manholes measures which will need thorough investigation. The culvert systems will need to be analysed checking joints and ensuring the system can cope when it becomes pressurised. The drainage network will also need to be reviewed to ensure there is sufficient capacity to deal with surface water/pluvial issues during a fluvial flood event.

4.4 CONSIDERATION OF LAND USE MANAGEMENT

Land Use Management methods were considered for all modelled watercourses in Lurgan. The proposed land use management method consists of various NFM features such as vegetation strips, storage bunds, and woodland creation such as agro forestry. The implementation of some or all of these features would have a cumulative effect of reducing flood risk to Lurgan. It is however difficult to quantify this reduction in flood risk through a hydraulic model. Given the uncertainty then associated with this method it is not appropriate to recommend it as part of the preferred option.

However, when considering climate change and the predicted increase in flood risk in the future, it has been commented, in the appraisal of options section, that the proposed options may need to be adapted in the future for climate change. It is therefore anticipated that the preferred option will not be able to provide the design SoP in the future (1% AEP plus climate change). As such the proposed NFM features would be an appropriate method to implement. In order to ascertain the effectiveness of these features monitoring would be required using data before and after the features have been placed. River gauges should therefore form part of the preferred option. The location of these gauges should be assessed in order to measure the effectiveness of the NFM features. It is also recommended that a long-term strategy be carried out working with the land owners to “buy in” to using their land for NFM. Other interested parties such as NIEA and available schemes such as the Environmental Farming Scheme should form part of this long-term strategy.

4.5 ECONOMIC ANALYSIS

RPS undertook a preliminary benefit-cost analysis to demonstrate the economic case for the identified options. This involved an assessment of the benefits (i.e. reducing flood impact) and the costs of the options over a 100 year design life span. This approach ensures that DfI Rivers has a robust economic argument which shows that the preferred option provides best value for money.

Full details of the Economic Appraisal can be found in the Lurgan Economic Appraisal Report. Details of the option costing and damage assessment assumptions are presented in Appendix C and Appendix D. Table 4.4 below summarises the results of the Economic Appraisal.

Table 4.4 - Summary of Economic Appraisal

	Costs (£)		
	Option 1	**Option 2**	**Option 3**
Construction costs from estimates	0	611,329	646,742
Optimism Bias Adjustment	0	297,106	318,197
Maintenance Costs (NPV over 100 years)	29,813	71,251	71,251
Total Present Value Costs	29,813	979,685	1,036,189
	Benefits (£)		
	Option 1	**Option 2**	**Option 3**
Present Value Damage	1,493,505	0	0
Present Value Damage Avoided	0	1,493,505	1,493,505
Intangible Damage	1,094,197	1,094,197	1,094,197
Total Present Value Damage Avoided	0	2,587,702	2,587,702
	Benefit Cost Ratio		
	Option 1	**Option 2**	**Option 3**
Average benefit/cost ratio	-	2.64	2.50

The results from the economic appraisal indicate that both options identified are economically viable although both are similar in price. Option 2 has a BCR of 2.64 whilst Option 3 has a BCR of 2.5 therefore Option 2 offers better value for money and is the recommended preferred option for the Lurgan Study Area.

4.6 SHORT TERM OPTIONS

RPS also considered the potential of interim or short-term methods that could be employed to reduce the flood risk to properties, without significantly increasing the risk of flooding elsewhere in the catchment.

4.6.1 Knocknashane (Flood Cell 1), Shankill (Flood Cell 2), Kiln Lodge (Flood Cell 3), North Circular Road (Flood Cell 4) and Drumnamoe (Flood Cell 5)

The following short-term methods have been carried forward to address the flood risk arising from Flood Cells 1,2,3,4 and 5:

- Temporary Defences
- Public Awareness Campaign
- Individual Property Protection

4.6.1.1 Assessment of Short-Term Methods

In the short-term, temporary defences method would provide a 'quick-win' through the use of sandbags around all properties. These methods may be implemented quickly to provide immediate protection to properties at risk of flooding in the area. The water depths during a 1% AEP event do not exceed 0.3m so protection could be provided to the required SoP. As depths are low, temporary defences may be a more economically viable option than individual property protection. However IPP could be used for properties which would require ring-fencing in sand bags. Implementation of the methods may create a small negative impact to residents, but only throughout the duration of flooding. Note these methods depend on persons implementing the protection and therefore may not be reliable.

A Public Awareness Campaign would not provide any formal protection to the areas at risk from out of bank flooding; however it would help residents take informed actions to protect their own properties. Each of the short-term methods would be relatively inexpensive to complete and would not have any adverse impacts.

4.6.2 Short-Term Options

From review of the methods appropriate for each flood mechanism, a preferred option was developed for short-term alleviation of flood risk.

Option 1:

- Temporary Defences
- Public Awareness Campaign
- Individual Property Protection

One preferred option was identified for the short-term alleviation of flood risk in Lurgan. A combination of Temporary Defences and Individual Property Protection were considered the best method to protect all properties at risk of flooding (as depths are less than 0.6m). A Public Awareness Campaign is also deemed to be a suitable method for reducing flood risk in the short-term in Lurgan.

5 RECOMMENDATIONS AND CONCLUSIONS

The option appraisal showed that both options would achieve the primary objective of providing the design Standard of Protection. Both options would have similar impacts when considering the other objectives and constraints identified however Option 2 is considered to be better value for money. Option 2 is therefore the recommended preferred option for the Lurgan Study Area.

Option 2 would provide the best cost beneficial solution. The total cost of the option was estimated to be £979,685 compared to the £1,036,189 estimated for Option 3. The total potential benefit was estimated at £2.59million therefore giving a cost benefit ratio of 2.64 for Option 2.

It is recommended that Land Use Management and NFM features be considered to provide further protection in the future. Recently there has been significant research into such methods for example the report prepared by the Research Agency of the Forestry Commission, Forest Research, titled *'Opportunity mapping for woodland creation to reduce flood risk in Northern Ireland'*. This report identified high priority areas for planting floodplain, riparian and wider catchment woodland to reduce downstream flood risk. As the effectiveness of these methods will likely rely on monitoring, river gauges would be required to be installed along with the short-term or long-term options.

Subject to approval from the Department for Infrastructure Economics Branch, Option 2 could progress to detailed design, subject to competing priorities and resources.

6 REFERENCES

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Supplementary Green Book Guidance on the treatment of optimism bias, HM Treasury (2002)

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APPENDIX A

CLASSIFICATION OF PROPERTIES AND DEPTHS OF FLOODING

FID	Use	MCM CODE	SA2011	Property Type	GL	Steps	Raised	FFL	AREA	Q100_Dp	Q75_Dp	Q50_Dp	Q25_Dp	Q10_Dp	Q5_Dp	Q2_Dp
0	R	115	N00002285	1975-1985 Detached	-999	-999	0.3	34.06	94.66	-0.62	-0.65	-0.69	-0.78	-999	-999	-999
1	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	33.93	47.04	-0.42	-0.43	-0.43	-0.51	-999	-999	-999
2	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	33.8	52.96	-0.25	-0.26	-0.26	-0.26	-999	-999	-999
3	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.19	43.99	-0.64	-0.65	-0.65	-0.65	-999	-999	-999
4	R	124	N00002286	1965-1974 Semi-Detached	-999	1	0.15	34.03	67.3	-0.6	-999	-999	-999	-999	-999	-999
5	R	124	N00002286	1965-1974 Semi-Detached	-999	1	0.15	34.09	71.01	-0.66	-0.71	-999	-999	-999	-999	-999
6	R	124	N00002286	1965-1974 Semi-Detached	-999	1	0.15	34.05	44.9	-0.62	-999	-999	-999	-999	-999	-999
7	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.52	51.81	-0.09	-0.14	-0.21	-999	-999	-999	-999
8	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.42	52.23	0.01	-0.04	-0.11	-999	-999	-999	-999
9	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.76	50.51	-0.33	-0.38	-0.45	-999	-999	-999	-999
10	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.76	78.83	-0.33	-0.38	-0.44	-999	-999	-999	-999
11	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.76	71.91	-0.33	-0.38	-0.44	-0.61	-999	-999	-999
12	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.58	102.81	-0.15	-0.2	-0.26	-0.43	-999	-999	-999
13	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.62	107.22	-0.19	-0.24	-0.3	-0.47	-999	-999	-999
14	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.77	51.1	-0.34	-0.39	-0.45	-0.62	-999	-999	-999
15	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.68	79.21	-0.25	-0.3	-0.36	-999	-999	-999	-999
16	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	33.82	51.33	-0.39	-0.44	-0.5	-0.67	-999	-999	-999
17	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.79	86.59	-0.36	-0.41	-0.47	-999	-999	-999	-999
18	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.93	80.27	-0.5	-0.55	-999	-999	-999	-999	-999
19	R	124	N00002286	1965-1974 Semi-Detached	-999	3	0.45	34.58	52.84	-0.64	-0.64	-0.64	-0.64	-999	-999	-999
20	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.75	51.27	-0.55	-0.55	-0.55	-0.55	-999	-999	-999
21	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.87	104.33	-0.51	-0.51	-0.51	-0.51	-999	-999	-999
22	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.86	110.14	-0.47	-0.47	-0.47	-0.48	-999	-999	-999
23	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.52	112.74	-0.25	-0.25	-999	-999	-999	-999	-999
24	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	33.91	65.4	-0.48	-999	-999	-999	-999	-999	-999
25	R	134	N00002286	1965-1974 Terrace	-999	3	0.45	34.09	76.15	-0.66	-999	-999	-999	-999	-999	-999
26	R	134	N00002286	1965-1974 Terrace	-999	3	0.45	34.04	75.66	-0.27	-999	-999	-999	-999	-999	-999
27	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.25	75.91	-0.42	-0.42	-999	-999	-999	-999	-999
28	R	134	N00002286	1965-1974 Terrace	-999	3	0.45	34.21	99.37	-0.78	-999	-999	-999	-999	-999	-999
29	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	33.98	78.25	-0.55	-0.6	-999	-999	-999	-999	-999
30	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.01	53.07	-0.58	-0.63	-0.69	-999	-999	-999	-999
31	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.86	51.13	-0.43	-0.48	-0.54	-999	-999	-999	-999
32	R	124	N00002286	1965-1974 Semi-Detached	-999	2	0.3	33.95	76.52	-0.52	-0.57	-0.63	-999	-999	-999	-999
33	R	125	N00002285	1975-1985 Semi-Detached	-999	3	0.45	34.78	92.71	-0.2	-0.2	-0.49	-999	-999	-999	-999
34	R	125	N00002285	1975-1985 Semi-Detached	-999	3	0.45	34.98	86.66	-0.34	-0.35	-999	-999	-999	-999	-999
35	R	125	N00002285	1975-1985 Semi-Detached	-999	3	0.45	35.09	53.68	-0.42	-0.42	-999	-999	-999	-999	-999
36	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.58	59.38	-0.32	-0.33	-0.33	-0.39	-999	-999	-999
37	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.38	54.42	-0.46	-0.46	-0.47	-0.55	-999	-999	-999
38	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.32	54.02	-0.46	-0.49	-0.5	-0.51	-999	-999	-999
39	R	125	N00002285	1975-1985 Semi-Detached	-999	3	0.45	34.96	53.22	-0.31	-0.41	-0.41	-0.42	-999	-999	-999
40	R	125	N00002285	1975-1985 Semi-Detached	-999	3	0.45	34.88	101.57	-0.47	-0.47	-0.47	-0.47	-999	-999	-999
41	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	34.81	50.42	-0.58	-999	-999	-999	-999	-999	-999
42	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.63	63.55	-0.2	-0.22	-0.25	-0.38	-999	-999	-999
43	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.56	73.61	-0.13	-0.15	-0.18	-0.31	-999	-999	-999
44	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.62	79.11	-0.19	-0.21	-0.24	-0.37	-999	-999	-999
45	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.66	49.01	-0.23	-0.25	-0.28	-0.41	-999	-999	-999
46	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.9	49.44	-0.47	-0.49	-0.52	-0.65	-999	-999	-999
47	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.96	72.49	-0.53	-0.55	-0.58	-0.71	-999	-999	-999
48	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.98	65.44	-0.55	-0.57	-0.6	-0.73	-999	-999	-999
49	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.96	67.49	-0.53	-0.55	-0.58	-0.71	-999	-999	-999
50	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	32.04	66.83	-0.61	-0.63	-0.66	-0.79	-999	-999	-999
51	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	32.01	62.47	-0.58	-0.6	-0.63	-0.76	-999	-999	-999
52	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.87	57.01	-0.44	-0.46	-0.49	-0.62	-999	-999	-999
53	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.78	56.55	-0.35	-0.37	-0.4	-0.53	-999	-999	-999
54	R	114	N00002287	1965-1974 Detached	-999	1	0.15	31.74	84.43	-0.32	-0.34	-0.36	-0.49	-999	-999	-999
55	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.06	68.74	-0.01	-0.03	-0.06	-0.2	-999	-999	-999
56	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31	75.14	0.05	0.03	0	-0.14	-999	-999	-999
57	R	124	N00002287	1965-1974 Semi-Detached	-999	0	0	31.04	57.06	0	-0.02	-0.04	-0.18	-999	-999	-999
58	R	124	N00002287	1965-1974 Semi-Detached	-999	0	0	31.27	61.34	-0.22	-0.24	-0.27	-0.41	-999	-999	-999
59	R	124	N00002287	1965-1974 Semi-Detached	-999	1	0.15	31.57	62.1	-0.52	-0.54	-0.57	-0.71	-999	-999	-999
60	R	124	N00002287	1965-1974 Semi-Detached	-999	0	0	31.71	61.52	-0.66	-0.68	-0.71	-0.85	-999	-999	-999
61	R	128	N00002392	post-1985 Semi-Detached	-999	2	0.3	31.03	73.6	-0.31	-0.33	-0.36	-0.5	-999	-999	-999
62	R	128	N00002392	post-1985 Semi-Detached	-999	2	0.3	31.05	71.66	-0.35	-0.37	-0.39	-0.57	-999	-999	-999
63	R	128	N00002392	post-1985 Semi-Detached	30.23	2	0.3	30.53	90.48	-0.07	-0.08	-0.09	-0.18	-999	-999	-999
64	R	128	N00002392	post-1985 Semi-Detached	30.25	2	0.3	30.55	71.67	0	-0.01	-0.03	-0.14	-999	-999	-999
65	R	134	N00002287	1965-1974 Terrace	-999	2	0.3	32.56	70.89	-0.14	-0.15	-0.16	-0.21	-999	-999	-999
66	R	134	N00002287	1965-1974 Terrace	-999	1	0.15	32.51	50.97	-0.07	-0.08	-0.09	-0.1	-999	-999	-999
67	R	134	N00002287	1965-1974 Terrace	-999	1	0.15	32.57	47.04	-0.13	-0.14	-0.15	-0.16	-999	-999	-999
68	R	134	N00002287	1965-1974 Terrace	-999	1	0.15	32.52	54.2	-0.08	-0.08	-0.09	-0.11	-999	-999	-999
69	R	134	N00002288	1965-1974 Terrace	-999	1	0.15	32.66	49.04	-0.19	-0.2	-0.21	-0.23	-999	-999	-999
70	R	134	N00002288	1965-1974 Terrace	-999	1	0.15	32.55	52.44	-0.08	-0.08	-0.09	-0.11	-999	-999	-999
71	R	134	N00002288	1965-1974 Terrace	-999	1	0.15	32.69	48.22	-0.21	-0.21	-0.22	-0.24	-999	-999	-999
72	R	134	N00002287	1965-1974 Terrace	-999	1	0.15	32.69	45.77	-0.22	-0.22	-0.24	-0.25	-999	-999	-999
73	R	134	N00002288	1965-1974 Terrace	-999	1	0.15	32.69	54.53	-0.21	-0.21	-0.22	-0.24	-999	-999	-999
74	R	134	N00002288	1965-1974 Terrace	32.45	1	0.15	32.6	56.76	0.01	0.01	0	-0.01	-999	-999	-999
75	R	134	N00002288	1965-1974 Terrace	32.36	1	0.15	32.51	58.39	0	-0.01	-0.02	-0.04	-999	-999	-999
76	R	134	N00002288	1965-1974 Terrace	32.46	1	0.15	32.61	55.48	-0.1	-0.11	-0.12	-0.13	-999	-999	-999
77	R	134	N00002288	1965-1974 Terrace	32.78	1	0.15	32.93	47.01	-0.32	-0.33	-0.33	-999	-999	-999	-999
78	R	118	N00002248	post-1985 Detached	-999	1	0.15	25.43	92.19	-0.41	-999	-999	-999	-999	-999	-999
79	R	118	N00002248	post-1985 Detached	-999	1	0.15	25.19	94.75	-0.47	-999	-999	-999	-999	-999	-999
80	R	118	N00002249	post-1985 Detached	-999	2	0.3	30.67	100.7	-0.27	-999	-999	-999	-999	-999	-999
81	R	118	N00002249	post-1985 Detached	-999	2	0.3	30.83	100.12	-0.43	-999	-999	-999	-999	-999	-999
82	R	118	N00002249	post-1985 Detached	-999	0	0	31.03	100.41	-0.63	-999	-999	-999	-999	-999	-999
83	R	125	N00002285	1975-1985 Semi-Detached	-999	1	0.15	34.13	133	-0.39	-0.39	-0.39	-0.39	-999	-999	-999
84	R	115	N00002285	1975-1985 Detached	-999	1	0.15	34.5	123.61	-1.06	-1.09	-1.13	-999	-999	-999	-999
85	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	34.12	60.34	-0.57	-0.57	-0.58	-0.58	-999	-999	-999

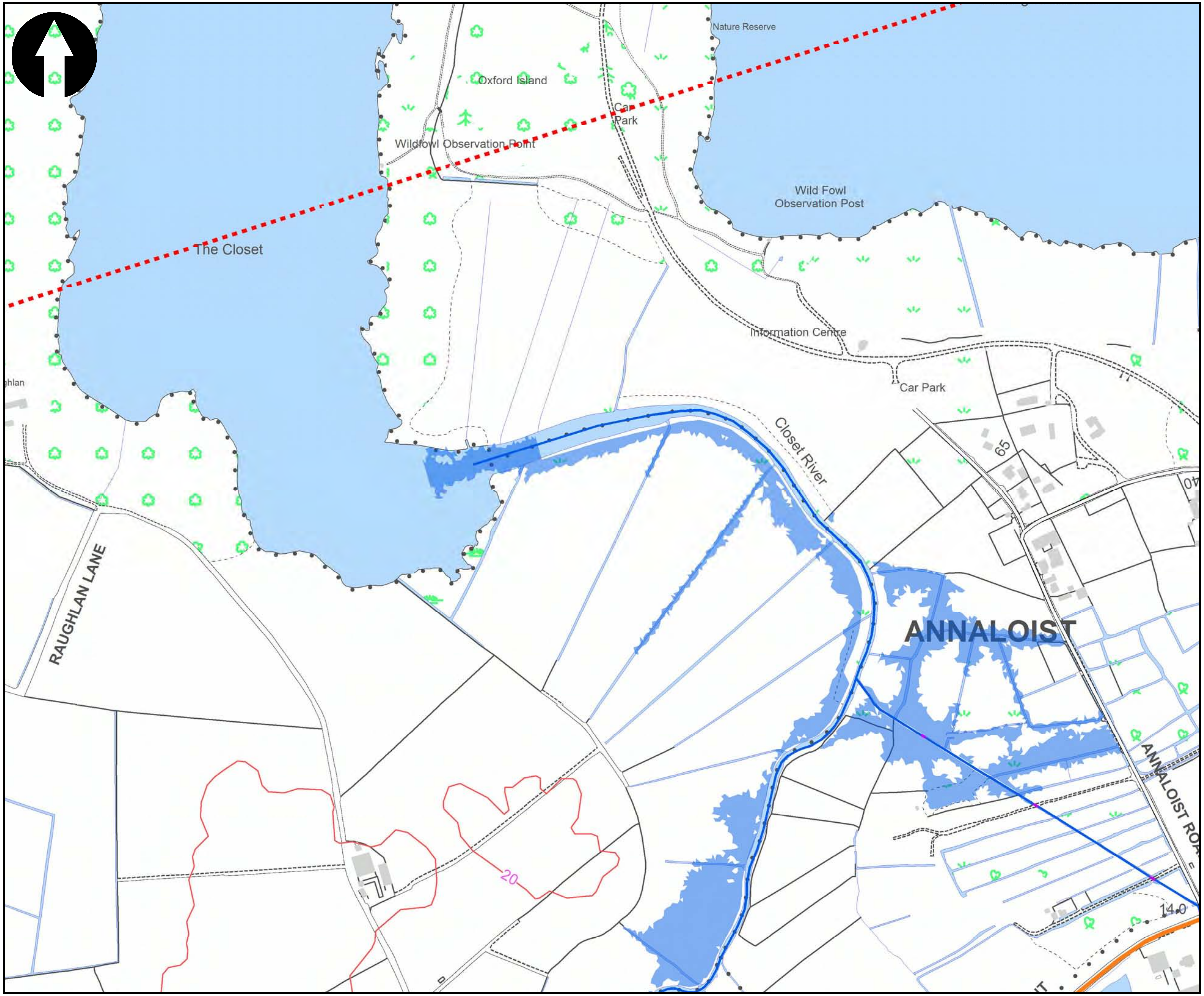
FID	Use	MCM CODE	SA2011	Property Type	GL	Steps	Raised	FFL	AREA	Q100_Dp	Q75_Dp	Q50_Dp	Q25_Dp	Q10_Dp	Q5_Dp	Q2_Dp
86	R	134	N00002286	1965-1974 Terrace	-999	2	0.3	33.73	42.84	-0.18	-0.19	-0.19	-0.19	-999	-999	-999
87	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.53	54.02	-0.2	-0.21	-0.22	-0.24	-999	-999	-999
88	R	124	N00002285	1965-1974 Semi-Detached	-999	3	0.45	36.36	49.36	-1.03	-1.04	-1.05	-999	-999	-999	-999
89	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	36.52	55.7	0.02	0.01	-999	-999	-999	-999	-999
90	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	36.66	61	-0.34	-0.35	-999	-999	-999	-999	-999
91	R	115	N00002285	1975-1985 Detached	-999	2	0.3	35.84	103.97	-0.4	-0.41	-0.41	-0.55	-999	-999	-999
92	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.73	56.02	-0.4	-0.41	-0.42	-0.44	-999	-999	-999
93	R	125	N00002285	1975-1985 Semi-Detached	-999	2	0.3	35.6	58.81	-0.27	-0.28	-0.29	-0.31	-999	-999	-999
94	R	118	N00002322	post-1985 Detached	-999	2	0.3	53.56	105.35	-0.62	-999	-999	-999	-999	-999	-999
95	R	118	N00002322	post-1985 Detached	-999	2	0.3	53.56	108.81	-0.61	-0.7	-999	-999	-999	-999	-999
96	R	118	N00002325	post-1985 Detached	-999	1	0.15	53.34	117.55	-0.39	-0.48	-999	-999	-999	-999	-999
97	R	118	N00002325	post-1985 Detached	-999	1	0.15	53.75	96.95	-0.74	-0.81	-0.91	-999	-999	-999	-999
98	R	118	N00002325	post-1985 Detached	-999	1	0.15	53.71	96.46	-0.63	-0.69	-999	-999	-999	-999	-999
99	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.35	111.54	-0.4	-0.49	-0.64	-999	-999	-999	-999
100	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.27	115.17	-0.31	-0.4	-0.53	-999	-999	-999	-999
101	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.21	91.78	-0.25	-0.34	-0.47	-999	-999	-999	-999
102	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.36	98.22	-0.38	-0.46	-0.53	-999	-999	-999	-999
103	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.41	111.79	-0.41	-0.47	-0.55	-999	-999	-999	-999
104	R	115	N00002322	1975-1985 Detached	-999	2	0.3	53.29	154.16	-0.28	-0.34	-0.42	-0.54	-999	-999	-999
105	R	118	N00002325	post-1985 Detached	-999	2	0.3	53.58	148.14	-0.54	-0.6	-0.67	-0.79	-999	-999	-999
106	R	115	N00002325	1975-1985 Detached	-999	2	0.3	53.86	165.23	-0.83	-0.9	-0.99	-1.11	-999	-999	-999
107	R	128	N00002325	post-1985 Semi-Detached	-999	-999	0.3	53.49	60.14	-0.45	-999	-999	-999	-999	-999	-999
108	R	128	N00002325	post-1985 Semi-Detached	-999	-999	0.3	53.31	59.47	-0.27	-0.33	-0.4	-999	-999	-999	-999
109	R	128	N00002325	post-1985 Semi-Detached	-999	-999	0.3	53.2	59.6	-0.16	-0.22	-0.29	-0.41	-999	-999	-999
110	R	118	N00002249	post-1985 Detached	-999	-999	0.3	30.98	100.41	-0.58	-0.71	-1.07	-999	-999	-999	-999
111	R	118	N00002249	post-1985 Detached	-999	-999	0.3	31.17	100.41	-0.77	-0.9	-1.17	-999	-999	-999	-999
112	R	118	N00002249	post-1985 Detached	-999	-999	0.3	31.3	100.41	-0.9	-1.03	-1.3	-999	-999	-999	-999
113	R	118	N00002249	post-1985 Detached	-999	-999	0.3	31.22	100.41	-0.82	-0.95	-1.22	-999	-999	-999	-999
114	R	124	N00002238	1965-1974 Semi-Detached	39.14	-999	0.3	39.44	37.43	-0.27	-999	-999	-999	-999	-999	-999
115	R	134	N00002288	1965-1974 Terrace	32.39	2	0.3	32.69	39.84	-0.3	-0.31	-0.36	-999	-999	-999	-999
116	R	118	N00002393	post-1985 Detached	29.76	3	0.45	30.21	150.75	-0.32	-0.33	-0.35	-999	-999	-999	-999
117	R	124	N00002238	1965-1974 Semi-Detached	39.16	-999	0.3	39.46	41.82	-0.29	-999	-999	-999	-999	-999	-999
118	C	52	N00002287	Sport	31.56	-999	0	31.56	354.5	-0.13	-0.15	-0.18	-0.31	-999	-999	-999
119	R	134	N00002283	1965-1974 Terrace	36.09	2	0.3	36.39	39.61	-0.31	-0.31	-0.44	-0.44	-999	-999	-999
120	R	134	N00002288	1965-1974 Terrace	32.3	1	0.15	32.45	37.73	-0.05	-0.07	-0.12	-0.39	-999	-999	-999
121	R	134	N00002288	1965-1974 Terrace	32.76	1	0.15	32.91	45.51	-0.15	-0.15	-0.15	-0.25	-999	-999	-999
122	R	134	N00002288	1965-1974 Terrace	32.12	2	0.3	32.42	66.12	-0.03	-0.04	-0.09	-0.36	-999	-999	-999
123	R	134	N00002238	1965-1974 Terrace	39.71	1	0.15	39.86	41.5	0.24	-999	-999	-999	-999	-999	-999
124	R	134	N00002288	1965-1974 Terrace	34.15	1	0.15	34.3	52.86	-0.32	-0.33	-0.33	-0.35	-999	-999	-999
125	R	128	N00002392	post-1985 Semi-Detached	30.39	3	0.45	30.84	72.74	-0.41	-0.42	-0.44	-999	-999	-999	-999
126	R	134	N00002288	1965-1974 Terrace	33.42	1	0.15	33.57	44.08	-0.06	-0.06	-0.31	-0.32	-999	-999	-999
127	R	134	N00002288	1965-1974 Terrace	33.19	1	0.15	33.34	51.82	-0.06	-0.07	-0.08	-0.1	-999	-999	-999
128	R	134	N00002288	1965-1974 Terrace	34.33	1	0.15	34.48	47.67	-0.09	-0.09	-0.09	-0.1	-999	-999	-999
129	R	134	N00002288	1965-1974 Terrace	33.83	1	0.15	33.98	59.37	0.19	0.18	0.18	0.17	-999	-999	-999
130	R	134	N00002283	1965-1974 Terrace	37.09	1	0.15	37.24	75.67	-0.03	-0.03	-0.04	-0.05	-999	-999	-999
131	R	134	N00002284	1965-1974 Terrace	34.06	1	0.15	34.21	45.57	-0.06	-0.06	-0.07	-0.08	-999	-999	-999
132	R	134	N00002284	1965-1974 Terrace	36.8	1	0.15	36.95	39.01	-0.09	-0.1	-0.1	-0.11	-999	-999	-999
133	R	134	N00002288	1965-1974 Terrace	34.26	1	0.15	34.41	44.23	-0.07	-0.07	-0.07	-0.07	-999	-999	-999
134	R	134	N00002283	1965-1974 Terrace	35.41	1	0.15	35.56	39.64	0.3	0.3	0.29	0.27	-999	-999	-999
135	R	134	N00002237	1965-1974 Terrace	38.24	1	0.15	38.39	59.19	-0.1	-0.12	-999	-999	-999	-999	-999
136	R	134	N00002288	1965-1974 Terrace	33.44	1	0.15	33.59	44.72	0	-0.01	-0.02	-0.05	-999	-999	-999
137	R	134	N00002283	1965-1974 Terrace	35.48	1	0.15	35.63	50.51	0.08	0.07	0.07	0.05	-999	-999	-999
138	R	134	N00002284	1965-1974 Terrace	36.54	1	0.15	36.69	38.74	-0.05	-0.05	-0.06	-0.12	-999	-999	-999
139	R	134	N00002288	1965-1974 Terrace	34.34	1	0.15	34.49	48.39	-0.17	-0.18	-0.18	-0.2	-999	-999	-999
140	R	134	N00002288	1965-1974 Terrace	32.79	1	0.15	32.94	44.66	-0.11	-0.11	-0.12	-0.2	-999	-999	-999
141	R	134	N00002237	1965-1974 Terrace	38.25	1	0.15	38.4	47.73	-0.06	-0.08	-999	-999	-999	-999	-999
142	R	128	N00002395	post-1985 Semi-Detached	29.95	3	0.45	30.4	61.76	-0.52	-0.53	-0.54	-999	-999	-999	-999
143	R	134	N00002238	1965-1974 Terrace	39.71	1	0.15	39.86	38.93	-0.13	-999	-999	-999	-999	-999	-999
144	R	134	N00002288	1965-1974 Terrace	33.21	1	0.15	33.36	46.79	-0.1	-0.11	-0.12	-0.14	-999	-999	-999
145	R	134	N00002238	1965-1974 Terrace	39.55	1	0.15	39.7	59.91	-0.34	-999	-999	-999	-999	-999	-999
146	R	134	N00002288	1965-1974 Terrace	32.18	2	0.3	32.48	39.9	-0.09	-0.1	-0.15	-0.42	-999	-999	-999
147	R	134	N00002288	1965-1974 Terrace	34.17	1	0.15	34.32	45.03	-0.14	-0.15	-0.15	-0.17	-999	-999	-999
148	R	134	N00002238	1965-1974 Terrace	39.67	1	0.15	39.82	40.34	-0.09	-999	-999	-999	-999	-999	-999
149	R	134	N00002284	1965-1974 Terrace	33.95	1	0.15	34.1	50.15	0.05	0.05	0.04	0.03	-999	-999	-999
150	R	134	N00002238	1965-1974 Terrace	39.63	1	0.15	39.78	41.14	-0.13	-999	-999	-999	-999	-999	-999
151	R	134	N00002237	1965-1974 Terrace	38.23	1	0.15	38.38	55.33	-0.09	-0.11	-999	-999	-999	-999	-999
152	R	134	N00002288	1965-1974 Terrace	33.15	1	0.15	33.3	46.71	-0.04	-0.05	-0.06	-0.07	-999	-999	-999
153	R	134	N00002239	1965-1974 Terrace	39.03	2	0.3	39.33	45.75	-0.34	-0.35	-0.36	-999	-999	-999	-999
154	R	118	N00002393	post-1985 Detached	28.99	3	0.45	29.44	91.38	-0.2	-0.2	-0.2	-999	-999	-999	-999
155	R	134	N00002284	1965-1974 Terrace	34.01	1	0.15	34.16	45.91	-0.01	-0.01	-0.02	-0.03	-999	-999	-999
156	R	134	N00002237	1965-1974 Terrace	38.19	1	0.15	38.34	43.2	0	-0.01	-0.12	-999	-999	-999	-999
157	R	128	N00002392	post-1985 Semi-Detached	30	3	0.45	30.45	100.8	-0.13	-0.15	-0.17	-0.36	-999	-999	-999
158	R	134	N00002288	1965-1974 Terrace	33.52	1	0.15	33.67	48.2	-0.08	-0.1	-0.12	-0.16	-999	-999	-999
159	R	134	N00002284	1965-1974 Terrace	36.81	1	0.15	36.96	38.73	-0.05	-0.06	-0.06	-0.07	-999	-999	-999
160	R	134	N00002284	1965-1974 Terrace	34.1	1	0.15	34.25	44.47	-0.09	-0.1	-0.11	-0.12	-999	-999	-999
161	R	128	N00002395	post-1985 Semi-Detached	29.75	3	0.45	30.2	64.55	-0.27	-0.28	-0.3	-0.5	-999	-999	-999
162	R	134	N00002288	1965-1974 Terrace	32.31	2	0.3	32.61	40.5	-0.22	-0.23	-0.28	-999	-999	-999	-999
163	R	134	N00002288	1965-1974 Terrace	33.98	1	0.15	34.13	72.21	-0.11	-0.12	-0.13	-0.15	-999	-999	-999
164	R	128	N00002392	post-1985 Semi-Detached	30.16	3	0.45	30.61	75.37	-0.29	-0.31	-0.33	-0.52	-999	-999	-999
165	R	134	N00002283	1965-1974 Terrace	36.21	-999	0.3	36.51	41.68	-0.19	-0.19	-0.2	-0.21	-999	-999	-999
166	R	134	N00002283	1965-1974 Terrace	35.61	3	0.45	36.06	49.56	-0.49	-0.49	-0.5	-0.51	-999	-999	-999
167	R	134	N00002284	1965-1974 Terrace	35.04	2	0.3	35.34	36.79	-0.48	-0.48	-0.49	-0.51	-999	-999	-999
168	R	134	N00002284	1965-1974 Terrace	33.7	1	0.15	33.85	84.19	0.3	0.3	0.29	0.28	-999	-999	-999
169	R	134	N00002284	1965-1974 Terrace	36.38	2	0.3	36.68	72.03	0.01	0.01	0	-0.01	-999	-999	-999
170	R	134	N00002238	1965-1974 Terrace	39.68	1	0.15	39.83	40.95	-0.1	-999	-999	-999	-999	-999	-999
171	R	134	N00002288	1965-1974 Terrace	32.4	2	0.3	32.7	50.48	-0.31	-0.32	-0.37	-999	-999	-999	-999

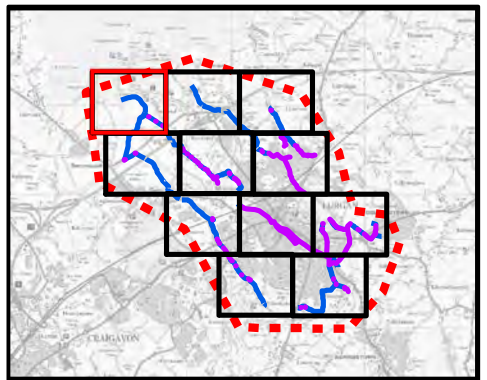
FID	Use	MCM CODE	SA2011	Property Type	GL	Steps	Raised	FFL	AREA	Q100_Dp	Q75_Dp	Q50_Dp	Q25_Dp	Q10_Dp	Q5_Dp	Q2_Dp
172	R	134	N00002237	1965-1974 Terrace	38.17	1	0.15	38.32	60	0.06	0.06	0.03	-999	-999	-999	-999
173	R	134	N00002284	1965-1974 Terrace	33.8	1	0.15	33.95	48.29	0.21	0.2	0.19	0.18	-999	-999	-999
174	R	128	N00002392	post-1985 Semi-Detached	30.42	3	0.45	30.87	65.27	-0.55	-0.57	-0.59	-999	-999	-999	-999
175	R	134	N00002288	1965-1974 Terrace	34.11	1	0.15	34.26	47.61	-0.22	-0.22	-0.22	-0.23	-999	-999	-999
176	R	134	N00002283	1965-1974 Terrace	35.42	1	0.15	35.57	36.8	0.14	0.13	0.13	0.11	-999	-999	-999
177	R	134	N00002284	1965-1974 Terrace	34.14	1	0.15	34.29	65.45	0.12	0.12	-0.15	-0.16	-999	-999	-999
178	R	134	N00002284	1965-1974 Terrace	36.52	1	0.15	36.67	41.63	-0.08	-0.08	-0.09	-0.1	-999	-999	-999
179	R	134	N00002288	1965-1974 Terrace	33.12	1	0.15	33.27	45.65	-0.32	-0.33	-0.55	-0.56	-999	-999	-999
180	R	134	N00002283	1965-1974 Terrace	37.14	1	0.15	37.29	38.62	-0.11	-0.11	-0.12	-0.13	-999	-999	-999
181	R	134	N00002288	1965-1974 Terrace	32.42	2	0.3	32.72	40.49	-0.33	-0.34	-0.39	-0.66	-999	-999	-999
182	R	134	N00002284	1965-1974 Terrace	33.83	1	0.15	33.98	48.19	0.18	0.17	0.17	0.15	-999	-999	-999
183	R	134	N00002284	1965-1974 Terrace	34.08	1	0.15	34.23	46.37	-0.08	-0.08	-0.09	-0.1	-999	-999	-999
184	R	134	N00002284	1965-1974 Terrace	34.3	1	0.15	34.45	70.66	-0.22	-0.23	-0.23	-0.25	-999	-999	-999
185	R	134	N00002288	1965-1974 Terrace	34.26	1	0.15	34.41	69.39	-0.34	-0.35	-0.35	-0.36	-999	-999	-999
186	R	134	N00002283	1965-1974 Terrace	35.46	1	0.15	35.61	49.36	0.25	0.25	0.24	0.22	-999	-999	-999
187	R	134	N00002288	1965-1974 Terrace	32.34	1	0.15	32.49	39.32	-0.09	-0.11	-0.15	-0.29	-999	-999	-999
188	R	134	N00002288	1965-1974 Terrace	33.21	1	0.15	33.36	46.06	-0.11	-0.12	-0.12	-0.13	-999	-999	-999
189	R	134	N00002288	1965-1974 Terrace	33.71	1	0.15	33.86	45.88	0.13	0.12	0.12	0.11	-999	-999	-999
190	R	134	N00002238	1965-1974 Terrace	39.72	1	0.15	39.87	40.52	-0.12	-999	-999	-999	-999	-999	-999
191	R	134	N00002288	1965-1974 Terrace	34.4	1	0.15	34.55	45.41	-0.35	-0.36	-0.38	-999	-999	-999	-999
192	R	128	N00002395	post-1985 Semi-Detached	29.94	3	0.45	30.39	62.05	-0.5	-0.51	-0.53	-0.69	-999	-999	-999
193	R	134	N00002288	1965-1974 Terrace	32.42	2	0.3	32.72	37.74	-0.33	-0.34	-0.39	-999	-999	-999	-999
194	R	134	N00002288	1965-1974 Terrace	33.22	1	0.15	33.37	43.24	-0.13	-0.13	-0.13	-0.14	-999	-999	-999
195	R	134	N00002283	1965-1974 Terrace	35.46	1	0.15	35.61	51.56	0.21	0.2	0.2	0.18	-999	-999	-999
196	R	134	N00002283	1965-1974 Terrace	36.15	-999	0.3	36.45	40.24	-0.19	-0.19	-0.2	-0.21	-999	-999	-999
197	R	134	N00002288	1965-1974 Terrace	33.18	1	0.15	33.33	51.66	-0.09	-0.09	-0.1	-0.1	-999	-999	-999
198	R	134	N00002288	1965-1974 Terrace	32.32	2	0.3	32.62	38.71	-0.23	-0.24	-0.29	-0.56	-999	-999	-999
199	R	134	N00002288	1965-1974 Terrace	32.4	1	0.15	32.55	40.14	-0.15	-0.17	-0.22	-0.49	-999	-999	-999
200	R	134	N00002284	1965-1974 Terrace	33.76	1	0.15	33.91	56.98	0.25	0.24	0.24	0.22	-999	-999	-999
201	R	134	N00002288	1965-1974 Terrace	34.37	1	0.15	34.52	47.72	-0.11	-0.11	-0.12	-0.12	-999	-999	-999
202	R	134	N00002284	1965-1974 Terrace	36.79	1	0.15	36.94	40.07	-0.06	-0.06	-0.07	-0.08	-999	-999	-999
203	R	134	N00002283	1965-1974 Terrace	35.47	1	0.15	35.62	37.14	0.24	0.23	0.22	0.21	-999	-999	-999
204	R	134	N00002284	1965-1974 Terrace	36.44	1	0.15	36.59	40.71	0.09	0.09	0.08	0.07	-999	-999	-999
205	R	134	N00002283	1965-1974 Terrace	37.17	1	0.15	37.32	39.72	-0.19	-0.19	-0.19	-0.19	-999	-999	-999
206	R	134	N00002237	1965-1974 Terrace	38.12	1	0.15	38.27	48.23	-0.16	-0.17	-999	-999	-999	-999	-999
207	R	134	N00002284	1965-1974 Terrace	34.05	1	0.15	34.2	43.7	-0.05	-0.05	-0.06	-0.07	-999	-999	-999
208	R	128	N00002392	post-1985 Semi-Detached	30.22	3	0.45	30.67	75.79	-0.35	-0.37	-0.39	-0.58	-999	-999	-999
209	R	134	N00002284	1965-1974 Terrace	36.43	1	0.15	36.58	39.81	-0.34	-0.34	-0.34	-0.34	-999	-999	-999
210	R	134	N00002288	1965-1974 Terrace	32.79	1	0.15	32.94	46.63	-0.22	-0.22	-0.23	-0.27	-999	-999	-999
211	R	134	N00002288	1965-1974 Terrace	32.3	2	0.3	32.6	71.14	-0.21	-0.22	-0.27	-0.54	-999	-999	-999
212	R	128	N00002392	post-1985 Semi-Detached	30.06	3	0.45	30.51	88.95	-0.19	-0.2	-0.23	-0.4	-999	-999	-999
213	R	134	N00002288	1965-1974 Terrace	33.18	1	0.15	33.33	47.62	-0.08	-0.09	-0.1	-0.11	-999	-999	-999
214	R	134	N00002238	1965-1974 Terrace	39.63	1	0.15	39.78	40.62	-0.05	-999	-999	-999	-999	-999	-999
215	R	134	N00002288	1965-1974 Terrace	33.2	1	0.15	33.35	49.55	-0.31	-0.32	-0.33	-0.35	-999	-999	-999
216	R	134	N00002283	1965-1974 Terrace	35.52	1	0.15	35.67	48.67	0.12	0.12	0.11	0.09	-999	-999	-999
217	R	134	N00002288	1965-1974 Terrace	33.88	1	0.15	34.03	48.16	-0.03	-0.04	-0.04	-0.06	-999	-999	-999
218	R	118	N00002392	post-1985 Detached	27.55	-999	0.3	27.85	158.73	-0.11	-0.11	-0.2	-999	-999	-999	-999
219	R	134	N00002284	1965-1974 Terrace	34	1	0.15	34.15	54.31	0	0	-0.01	-0.02	-999	-999	-999
220	R	128	N00002392	post-1985 Semi-Detached	30.41	3	0.45	30.86	73.91	-0.44	-0.45	-0.46	-999	-999	-999	-999
221	R	134	N00002238	1965-1974 Terrace	39.39	1	0.15	39.54	66.84	-0.37	-999	-999	-999	-999	-999	-999
222	R	134	N00002288	1965-1974 Terrace	33.22	1	0.15	33.37	48.66	-0.2	-0.2	-0.21	-0.22	-999	-999	-999
223	R	134	N00002283	1965-1974 Terrace	35.43	1	0.15	35.58	39.67	0.24	0.23	0.23	0.21	-999	-999	-999
224	R	134	N00002284	1965-1974 Terrace	36.41	1	0.15	36.56	43.22	-0.31	-0.31	-0.31	-0.32	-999	-999	-999
225	R	134	N00002283	1965-1974 Terrace	36.14	2	0.3	36.44	39.29	-0.03	-0.03	-0.04	-0.14	-999	-999	-999
226	R	134	N00002288	1965-1974 Terrace	33.75	1	0.15	33.9	44.78	0.09	0.08	0.08	0.07	-999	-999	-999
227	R	134	N00002283	1965-1974 Terrace	35.3	1	0.15	35.45	48.91	-0.17	-0.17	-0.17	-0.2	-999	-999	-999
228	R	134	N00002288	1965-1974 Terrace	33.51	1	0.15	33.66	44.36	-0.07	-0.08	-0.1	-0.13	-999	-999	-999
229	R	118	N00002393	post-1985 Detached	29.42	3	0.45	29.87	84.58	-0.21	-0.21	-0.21	-999	-999	-999	-999
230	R	134	N00002283	1965-1974 Terrace	36.18	2	0.3	36.48	39.41	-0.16	-0.16	-0.17	-0.18	-999	-999	-999
231	R	134	N00002283	1965-1974 Terrace	35.56	1	0.15	35.71	77.34	0.09	0.08	0.07	0.05	-999	-999	-999
232	R	134	N00002284	1965-1974 Terrace	36.66	1	0.15	36.81	39.64	-0.01	-0.01	-0.01	-0.02	-999	-999	-999
233	R	128	N00002395	post-1985 Semi-Detached	29.79	3	0.45	30.24	63.22	-0.22	-0.22	-0.22	-999	-999	-999	-999
234	R	134	N00002288	1965-1974 Terrace	32.65	1	0.15	32.8	44.52	0.09	0.09	0.03	0.01	-999	-999	-999
235	R	134	N00002288	1965-1974 Terrace	33.7	1	0.15	33.85	78.92	0.15	0.15	0.14	0.13	-999	-999	-999
236	R	134	N00002288	1965-1974 Terrace	34.09	1	0.15	34.24	49.21	-0.2	-0.2	-0.2	-999	-999	-999	-999
237	R	134	N00002288	1965-1974 Terrace	32.04	2	0.3	32.34	65.38	0.05	0.04	-0.01	-0.28	-999	-999	-999
238	R	134	N00002237	1965-1974 Terrace	38.24	1	0.15	38.39	49.94	-0.1	-0.12	-999	-999	-999	-999	-999
239	R	134	N00002284	1965-1974 Terrace	36.31	1	0.15	36.46	49.09	-0.22	-0.22	-0.22	-0.22	-999	-999	-999
240	R	118	N00002393	post-1985 Detached	27.83	3	0.45	28.28	79.22	-0.4	-0.4	-0.41	-999	-999	-999	-999
241	R	134	N00002288	1965-1974 Terrace	33.88	1	0.15	34.03	47.13	-0.01	-0.02	-0.03	-0.05	-999	-999	-999
242	R	134	N00002283	1965-1974 Terrace	35.45	1	0.15	35.6	36.57	0.22	0.21	0.21	0.19	-999	-999	-999
243	R	134	N00002288	1965-1974 Terrace	33.65	1	0.15	33.8	54.88	0.18	0.18	0.17	0.16	-999	-999	-999
244	R	134	N00002283	1965-1974 Terrace	35.26	1	0.15	35.41	51.7	-0.11	-0.11	-0.11	-999	-999	-999	-999
245	R	134	N00002284	1965-1974 Terrace	34.45	1	0.15	34.6	72.98	-0.29	-0.3	-0.3	-999	-999	-999	-999
246	R	134	N00002284	1965-1974 Terrace	34.33	1	0.15	34.48	55.34	-0.19	-0.25	-0.26	-999	-999	-999	-999
247	R	134	N00002284	1965-1974 Terrace	34.53	1	0.15	34.68	45.2	-0.05	-0.22	-0.23	-999	-999	-999	-999
248	R	134	N00002287	1965-1974 Terrace	33.04	1	0.15	33.19	48.69	-0.13	-0.14	-0.15	-999	-999	-999	-999
249	R	134	N00002287	1965-1974 Terrace	33.08	1	0.15	33.23	46.97	-0.17	-0.18	-0.19	-999	-999	-999	-999
250	R	134	N00002288	1965-1974 Terrace	32.29	2	0.3	32.59	40.79	-0.2	-0.21	-0.26	-999	-999	-999	-999
251	R	134	N00002288	1965-1974 Terrace	32.6	1	0.15	32.75	48.44	-0.12	-0.13	-0.14	-999	-999	-999	-999
252	R	134	N00002288	1965-1974 Terrace	32.44	1	0.15	32.59	51.62	0.04	0.03	0.03	-999	-999	-999	-999
253	R	134	N00002288	1965-1974 Terrace	32.77	1	0.15	32.92	47.53	-0.25	-0.26	-0.27	-0.29	-999	-999	-999
254	R	118	N00002392	post-1985 Detached	28.41	3	0.45	28.86	97.98	-0.06	-0.06	-0.06	-999	-999	-999	-999
255	R	148	N00002392	post-1985 Bungalow	28.94	-999	0.3	29.24	141.42	-0.1	-0.1	-0.1	-999	-999	-999	-999
256	R	148	N00002392	post-1985 Bungalow	27.91	3	0.45	28.36	105.34	-0.06	-0.06	-0.06	-999	-999	-999	-999
257	R	118	N00002392	post-1985 Detached	27.64	-999	0.3	27.94	105.59	-0.49	-0.49	-0.5	-999	-999	-999	-999

FID	Use	MCM CODE	SA2011	Property Type	GL	Steps	Raised	FFL	AREA	Q100_Dp	Q75_Dp	Q50_Dp	Q25_Dp	Q10_Dp	Q5_Dp	Q2_Dp
258	R	134	N00002283	1965-1974 Terrace	36.08	1	0.15	36.23	51.16	-0.15	-999	-999	-999	-999	-999	-999
259	R	134	N00002283	1965-1974 Terrace	36.08	1	0.15	36.23	39.75	-0.12	-0.14	-999	-999	-999	-999	-999
260	R	134	N00002284	1965-1974 Terrace	34.91	1	0.15	35.06	48.31	-0.15	-0.15	-0.15	-999	-999	-999	-999
261	R	134	N00002284	1965-1974 Terrace	34.92	1	0.15	35.07	44.66	-0.05	-0.05	-0.07	-999	-999	-999	-999
262	R	134	N00002284	1965-1974 Terrace	35.95	1	0.15	36.1	40.1	-0.17	-0.17	-999	-999	-999	-999	-999
263	R	134	N00002284	1965-1974 Terrace	34.91	1	0.15	35.06	45.34	-0.22	-0.22	-999	-999	-999	-999	-999
264	R	134	N00002284	1965-1974 Terrace	34.91	1	0.15	35.06	49.16	-0.22	-0.22	-0.92	-999	-999	-999	-999
265	R	134	N00002288	1965-1974 Terrace	34.21	0	0	34.21	53.73	0.15	0.14	-999	-999	-999	-999	-999
266	R	134	N00002284	1965-1974 Terrace	34.31	1	0.15	34.46	47.49	-0.22	-0.23	-0.24	-999	-999	-999	-999
267	R	134	N00002284	1965-1974 Terrace	34.5	1	0.15	34.65	70.45	0.08	-999	-999	-999	-999	-999	-999
268	R	134	N00002284	1965-1974 Terrace	35.95	1	0.15	36.1	46.09	-0.58	-0.58	-999	-999	-999	-999	-999
269	R	134	N00002288	1965-1974 Terrace	32.9	3	0.45	33.35	73.35	-0.95	-0.97	-1.02	-999	-999	-999	-999
270	R	124	N00002287	1965-1974 Semi-Detached	31.68	1	0.15	31.83	61.77	-0.78	-0.8	-0.83	-999	-999	-999	-999

APPENDIX B

RISK MAPS





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Legend

Properties with 1% AEP £ Damage
- Commerical
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Roads Network
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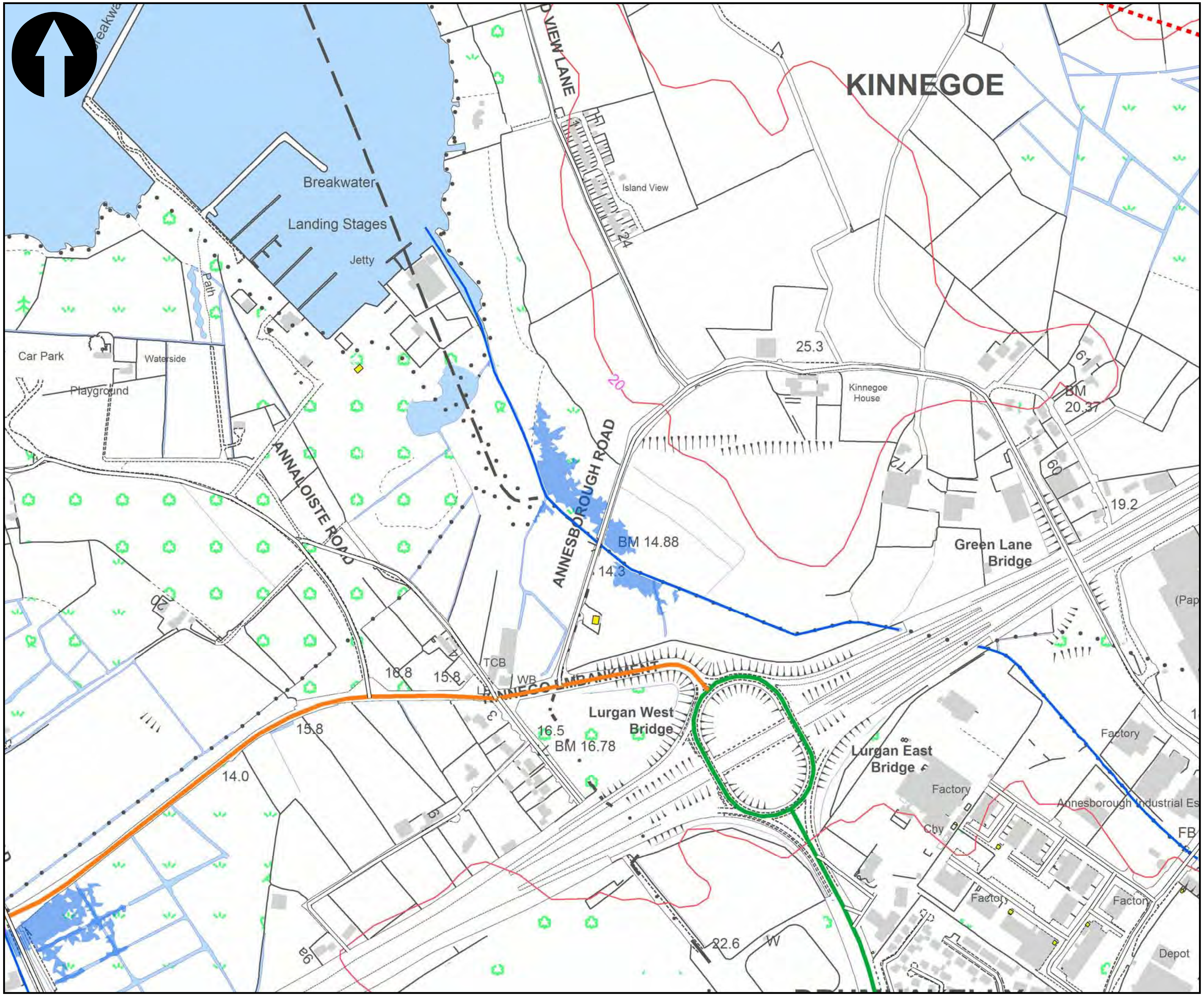
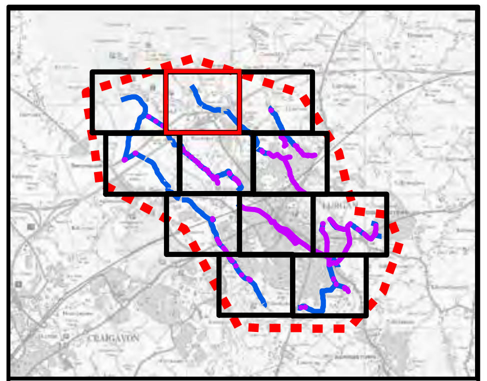
Map:
Lurgan Fluvial Economic Risk Map

Map Type: General Risk - Economic
Source: Fluvial
Map Area:
Scenario: Current
Drawn By : J.D. **Date :** 16th February 2018
Checked By : M.W. **Date :** 16th February 2018
Approved By : G.G. **Date :** 16th February 2018
Drawing No. :

Map Series : Page 1 of 11
Drawing Scale : 1:5,000 @ A3





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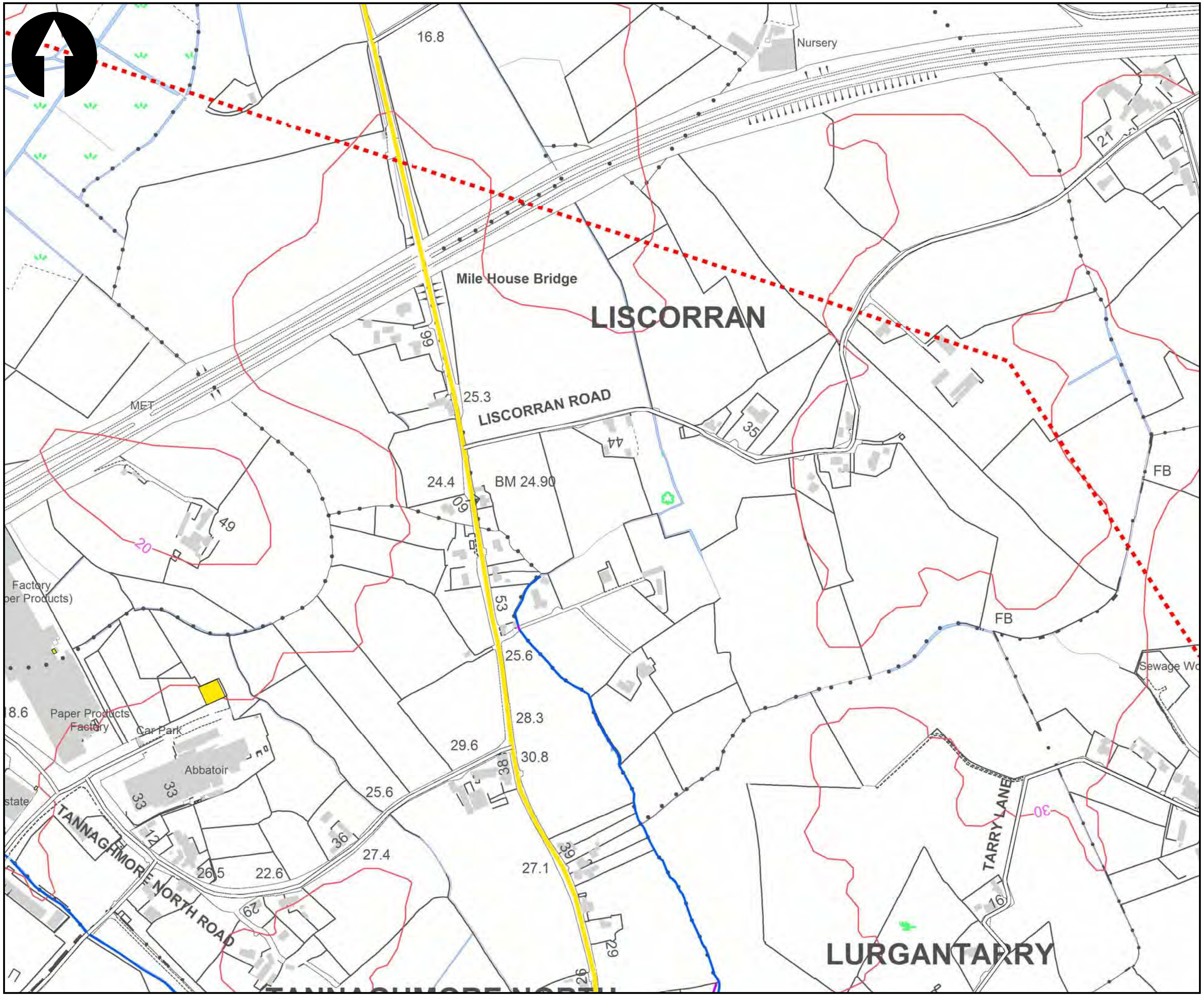

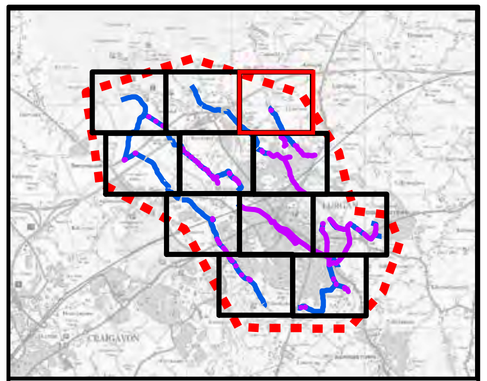

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Approved By :	G.G.	Date :	16th February 2018
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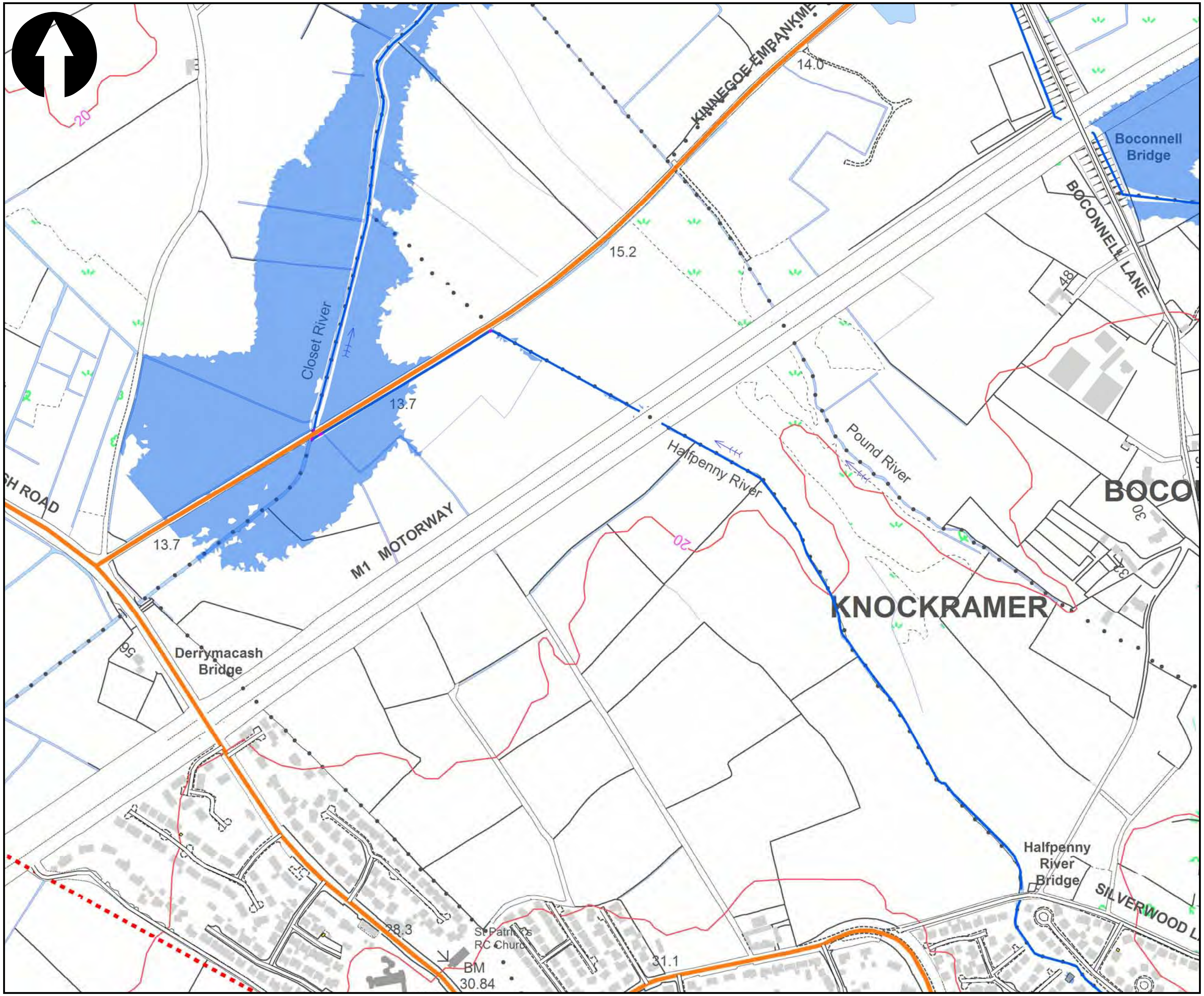

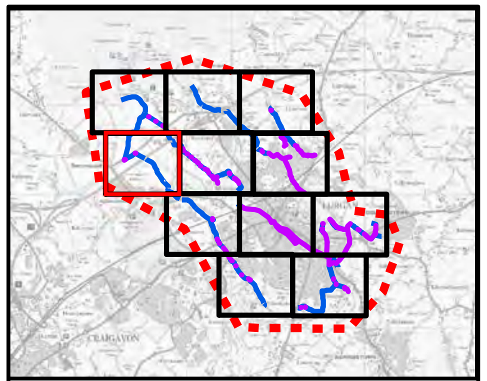

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Approved By : G.G.	Date : 16th February 2018
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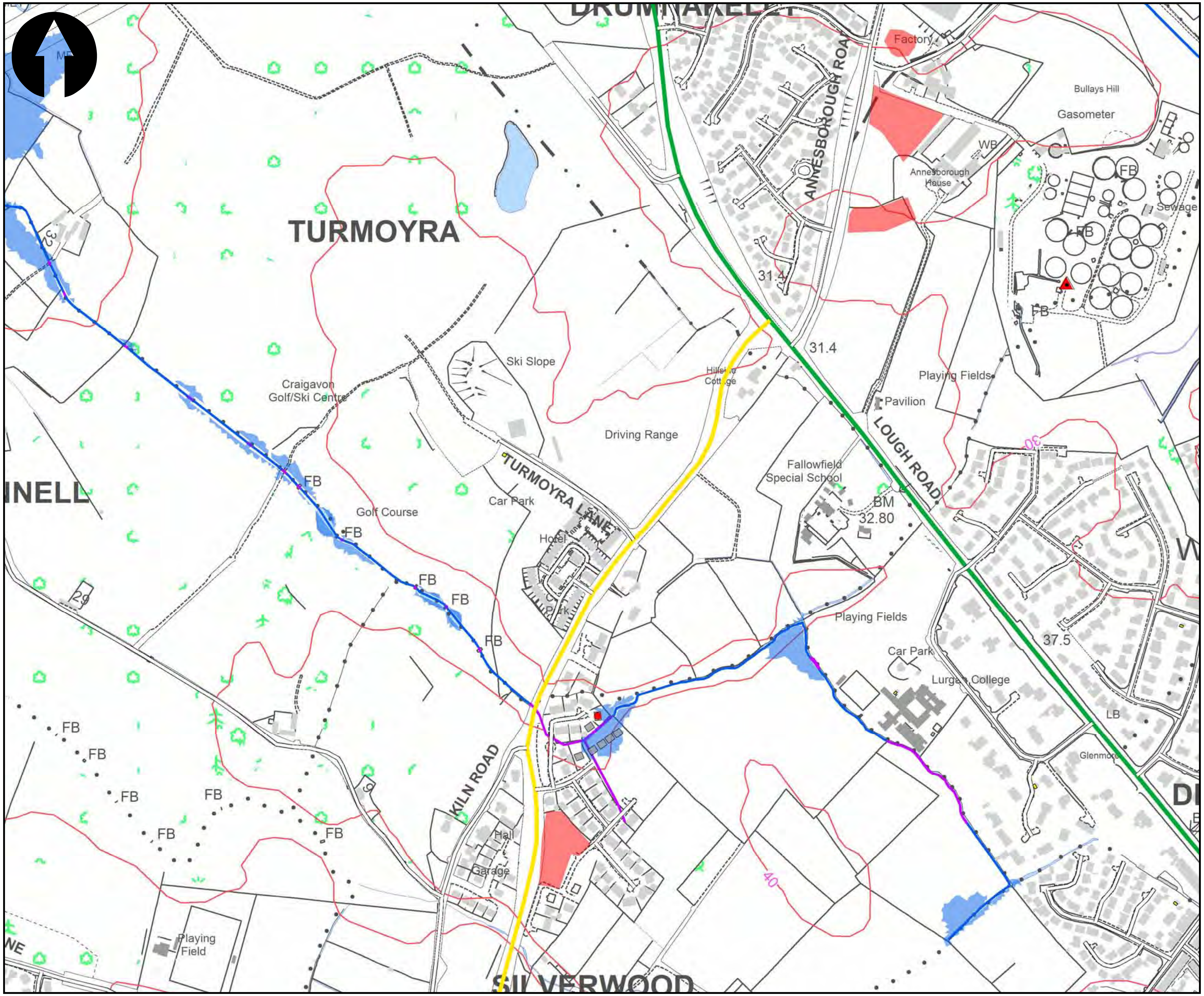

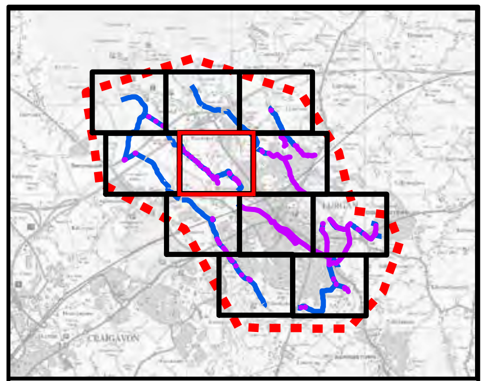

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Approved By : G.G.	Date : 16th February 2018
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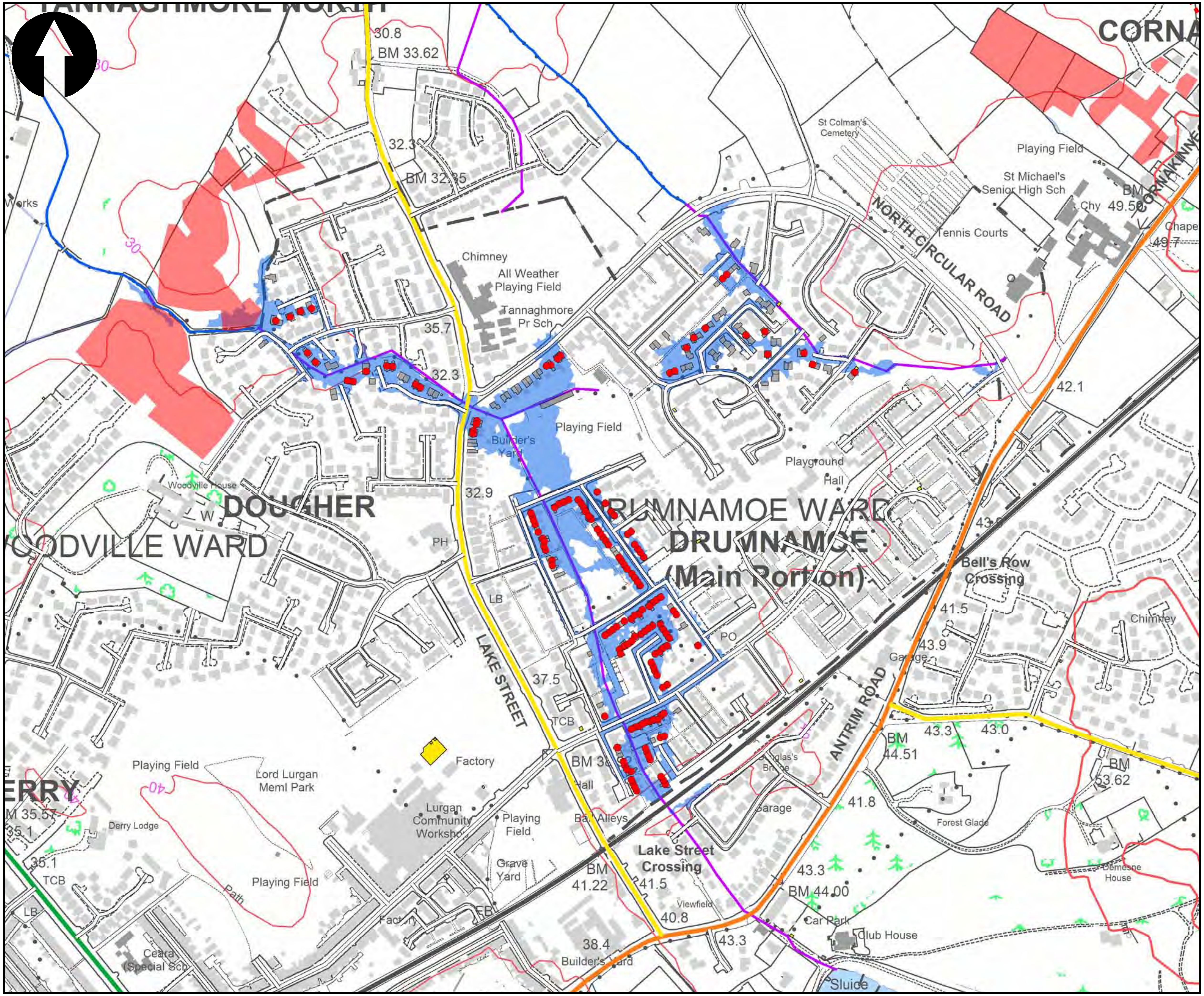

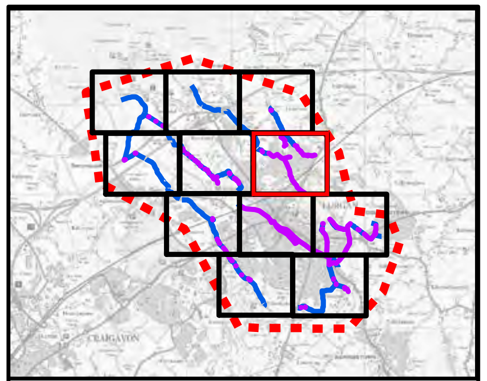

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Checked By : M.W. Date : 16th February 2018
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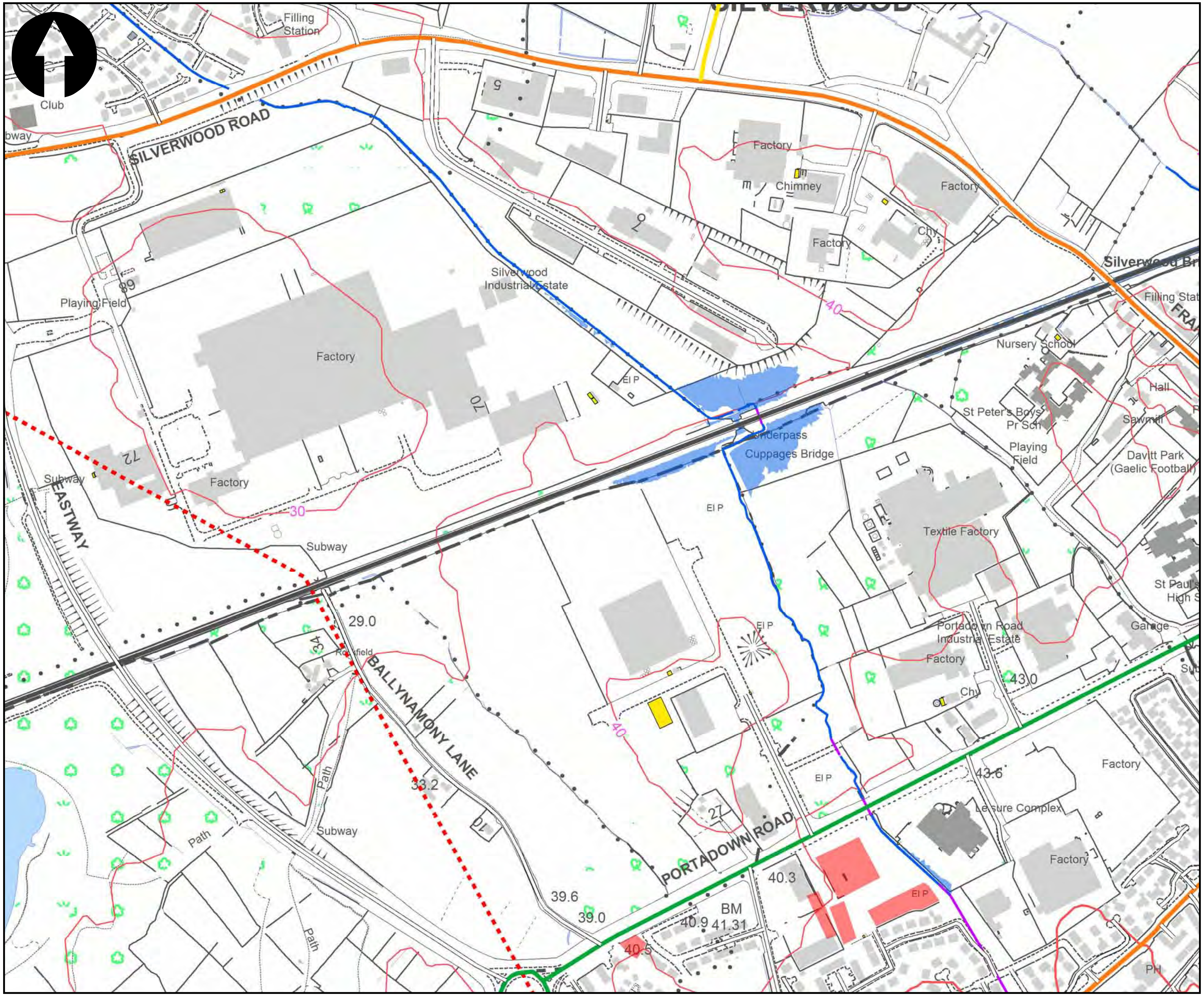

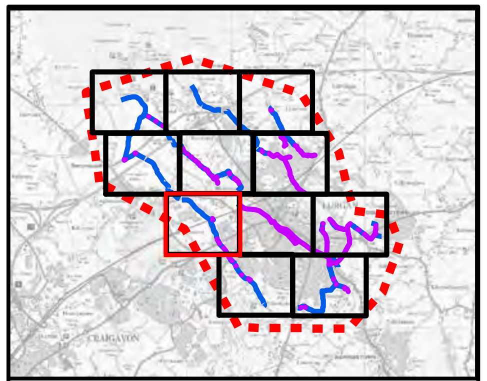

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Approved By : G.G.		**Date : 16th February 2018**
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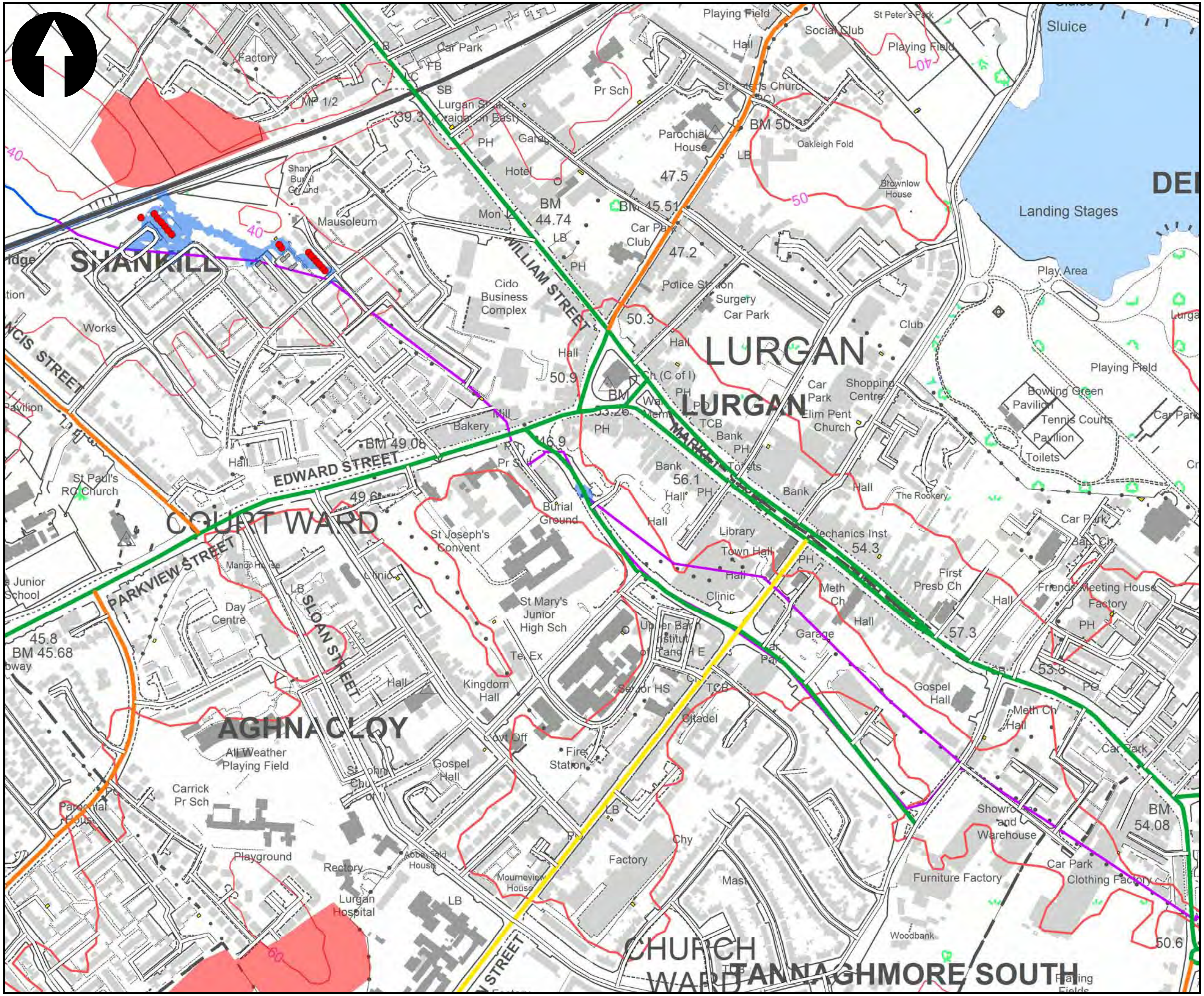

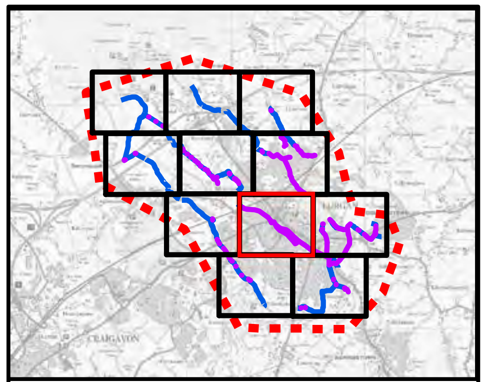

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Drawn By : J.D. Date : 16th February 2018
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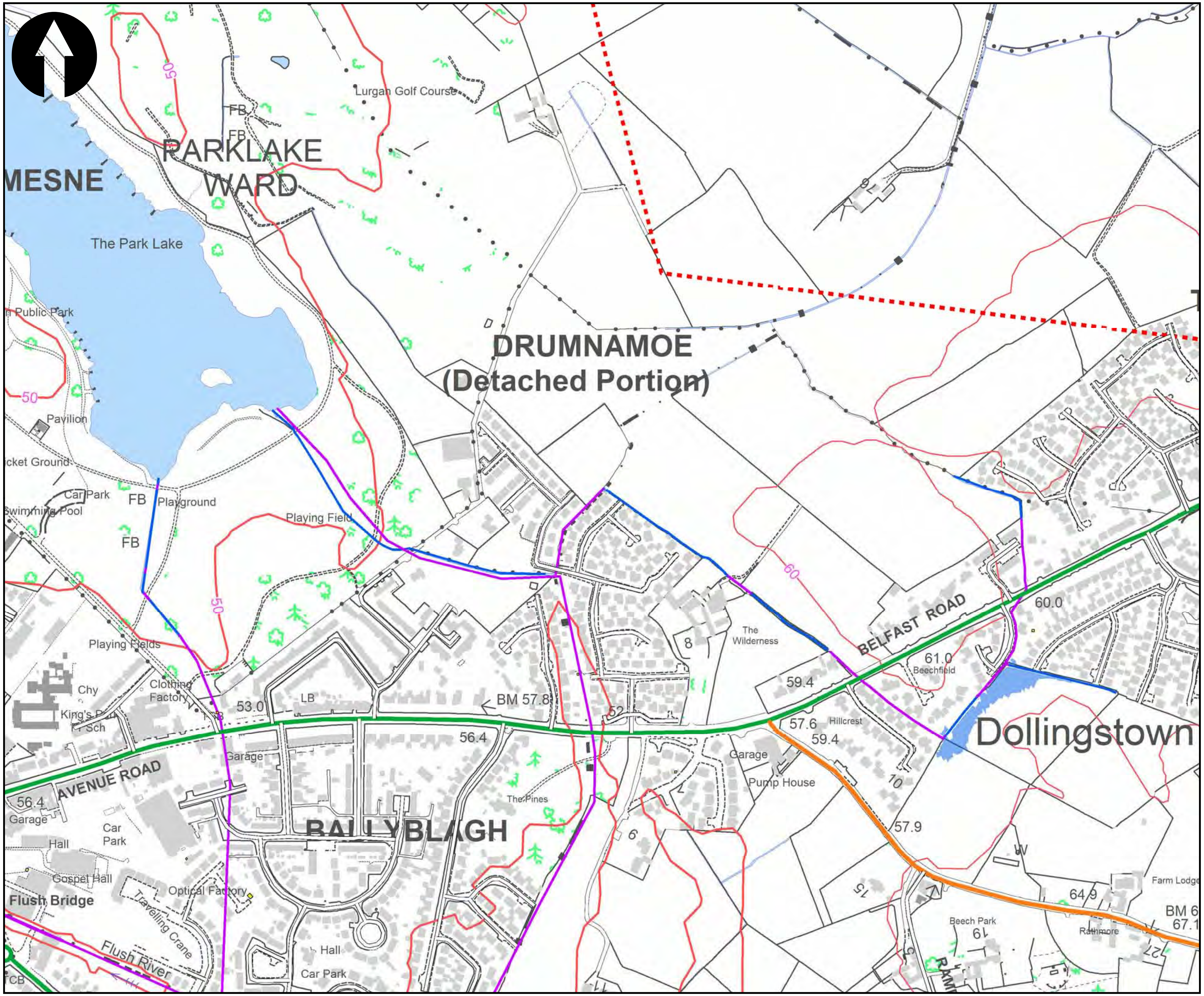
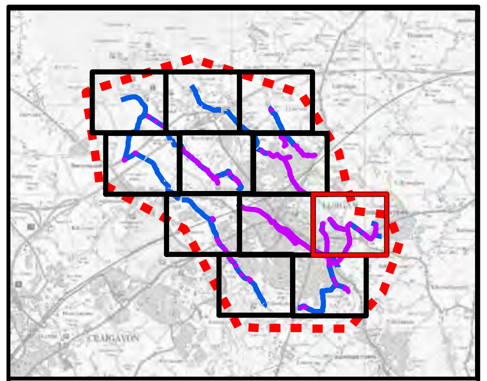
Map Series : Page 8 of 11

Drawing Scale : 1:5,000 @ A3





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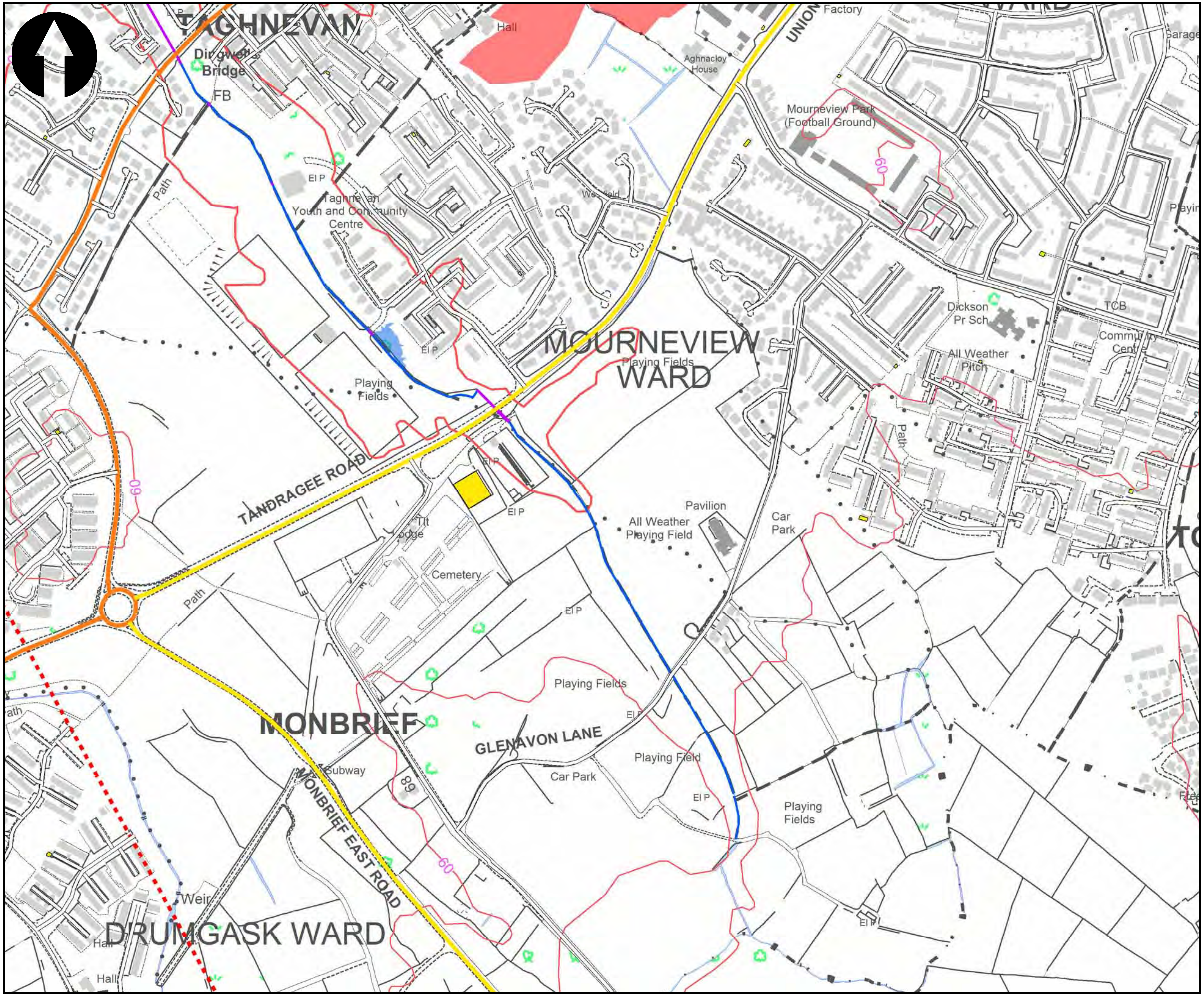

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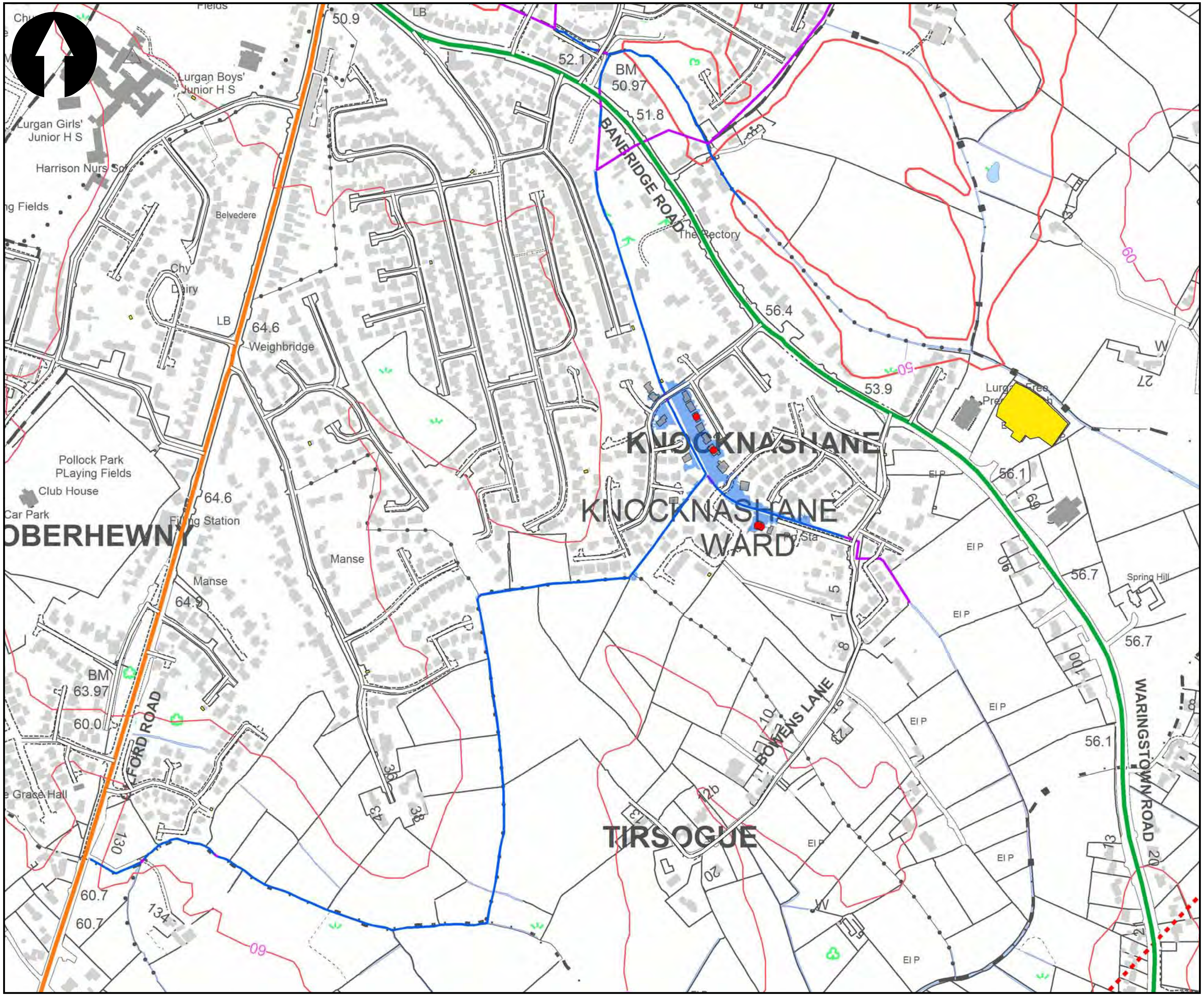

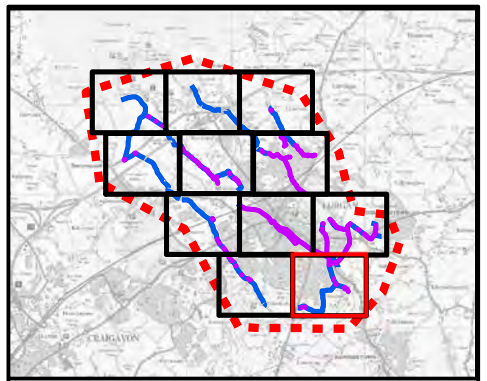

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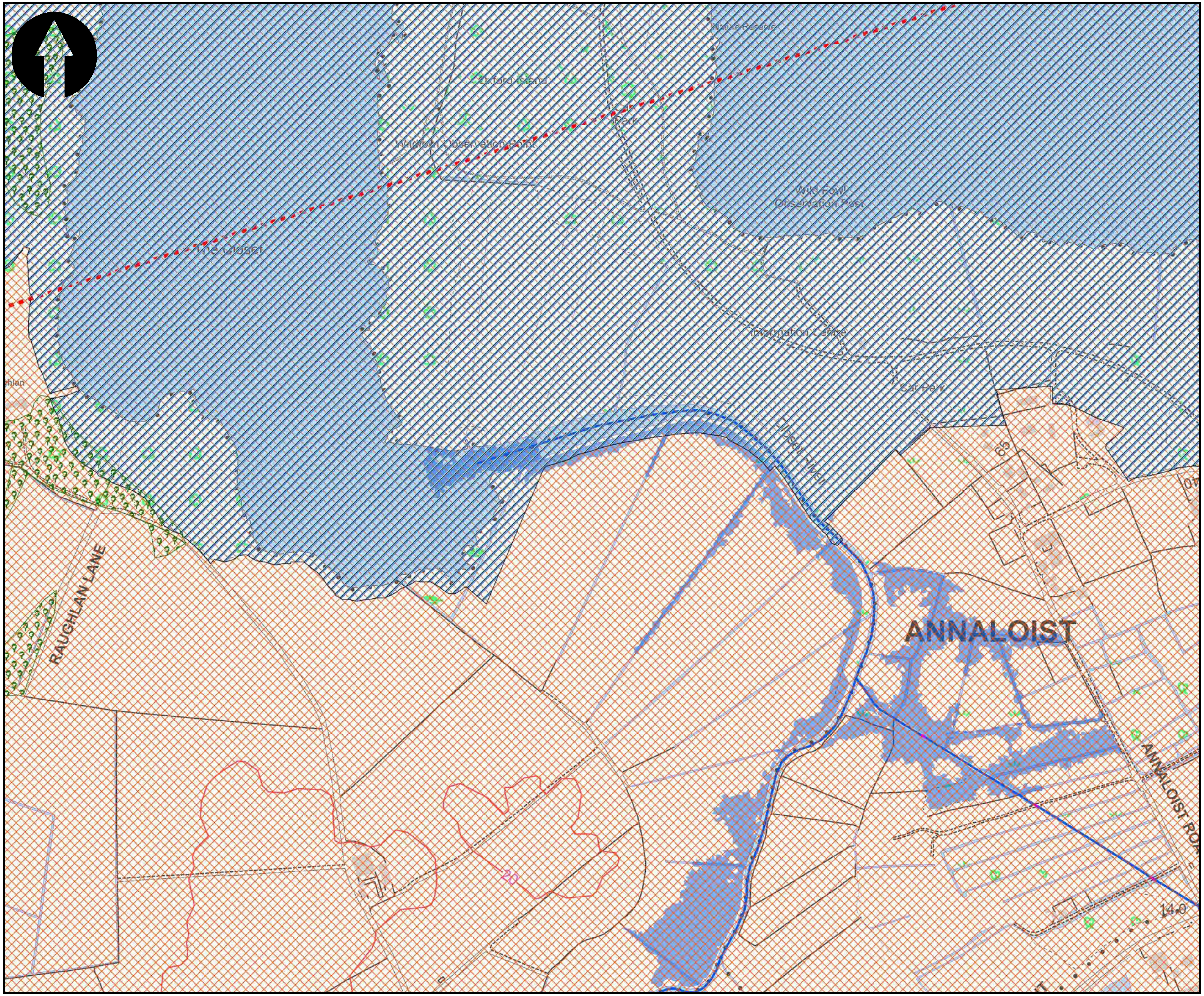
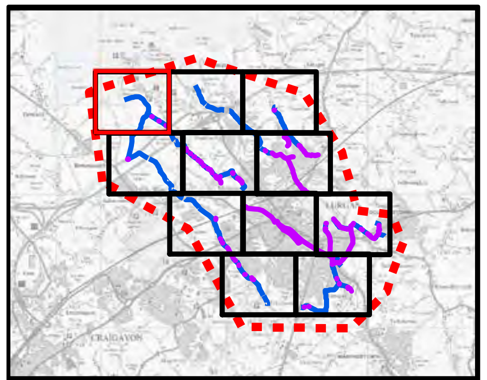
Map:
Lurgan Fluvial Economic Risk Map

Map Type: General Risk - Economic
Source: Fluvial
Map Area:
Scenario: Current
Drawn By : J.D. **Date :** 16th February 2018
Checked By : M.W. **Date :** 16th February 2018
Approved By : G.G. **Date :** 16th February 2018
Drawing No. :

Map Series : Page 11 of 11
Drawing Scale : 1:5,000 @ A3





IMPORTANT USER NOTE:
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

Legend

- Salmonid Rivers
- Ancient Woodland
- Area of Specific Scientific Interest (ASSI)
- Area of Natural Beauty (AONB)
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- RAMSAR
- 1% AEP Flood Extent
- Lurgan Study Area
- Conduit
- River Centreline

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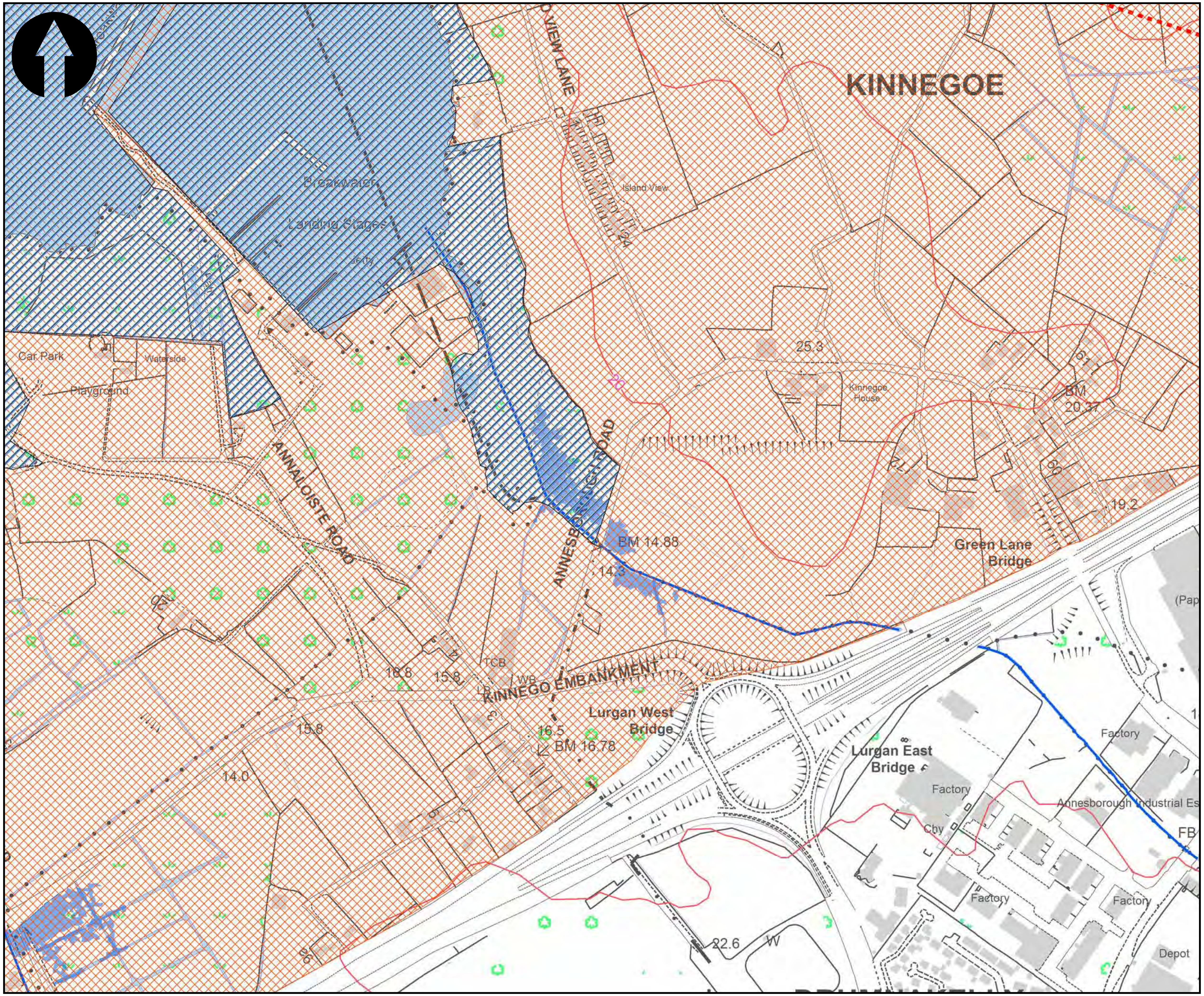
Map:
Portadown Fluvial Environmental Risk Map

Map Type:	General Risk - Environmental
Source:	Fluvial
Map Area:	
Scenario:	Current
Drawn By : J.D.	Date : 19th February 2018
Checked By : M.W.	Date : 19th February 2018
Approved By : G.G.	Date : 19th February 2018
Drawing No. :	
Map Series : Page 1 of 11	
Drawing Scale : 1:5,000 @ A3	



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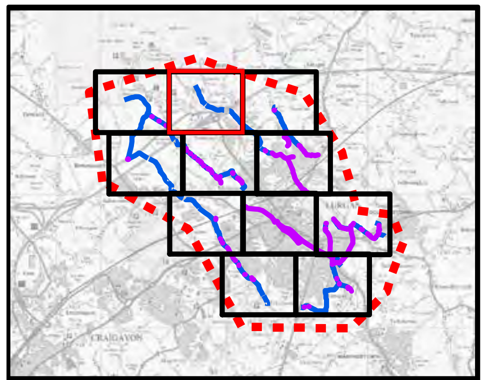

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Legend

- Salmonid Rivers
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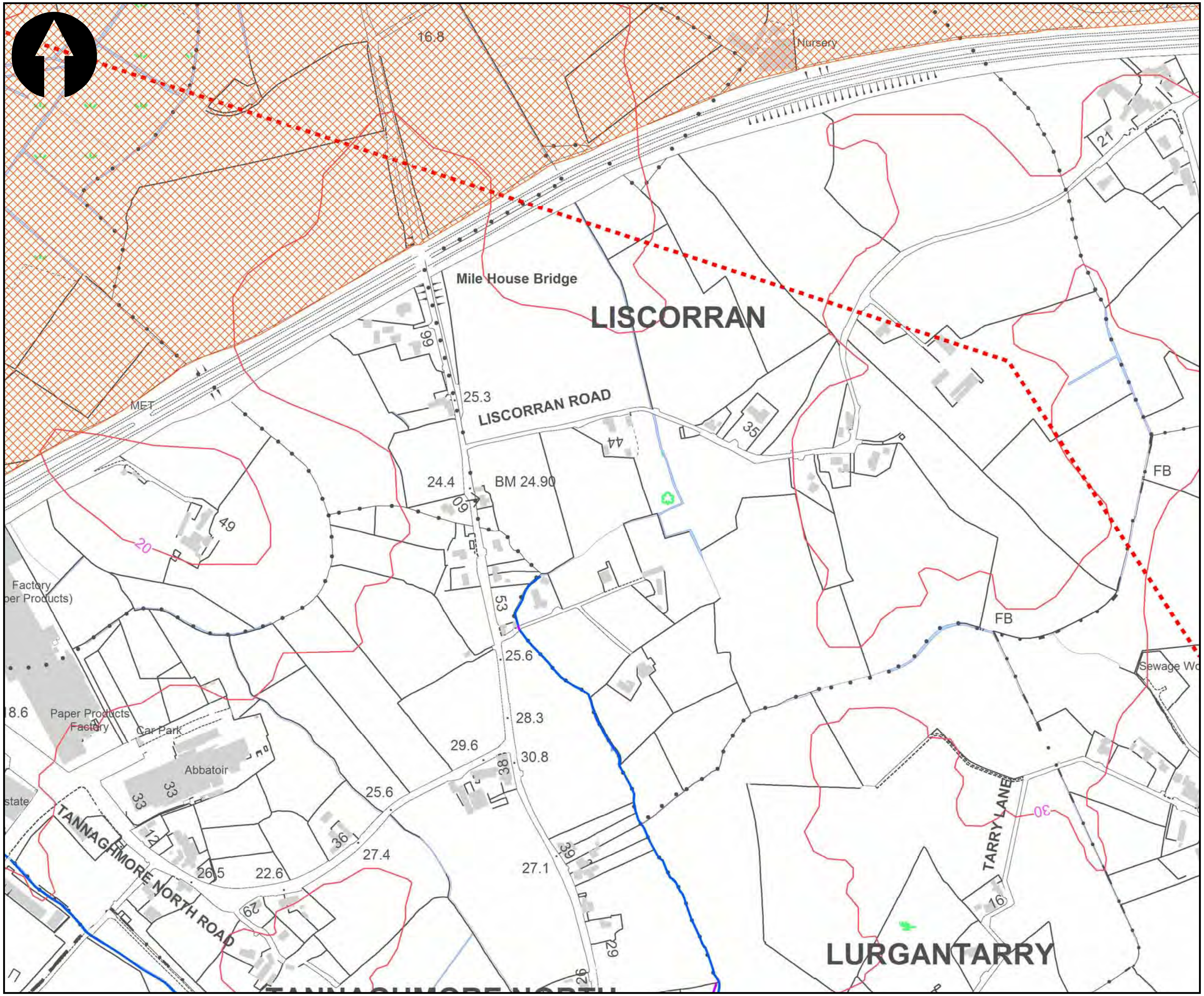
Map:
Portadown Fluvial Environmental Risk Map

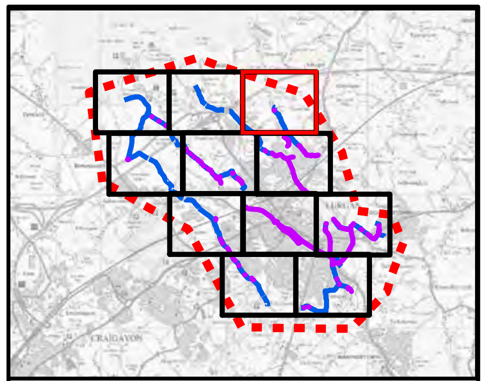
Map Type: General Risk - Environmental
Source: Fluvial
Map Area:
Scenario: Current

Drawn By : J.D. Date : 19th February 2018
Checked By : M.W. Date : 19th February 2018
Approved By : G.G. Date : 19th February 2018

Drawing No. :

Drawing Scale : 1:5,000 @ A3





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Legend

- Salmonid Rivers
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Map: Portadown Fluvial Environmental Risk Map

Map Type: General Risk - Environmental

Source: Fluvial

Map Area:

Scenario: Current

Drawn By : J.D. **Date :** 19th February 2018

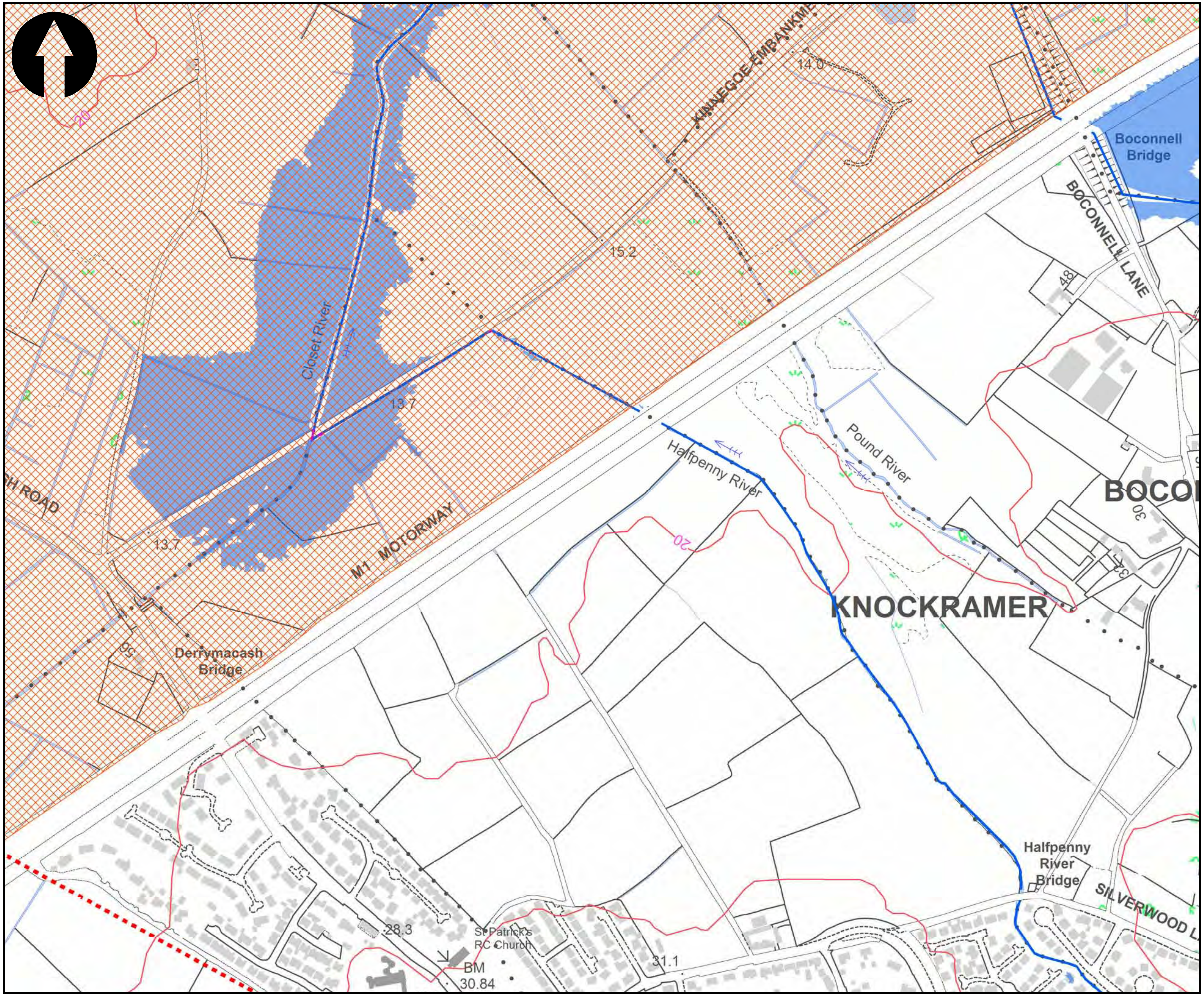
Checked By : M.W. **Date :** 19th February 2018

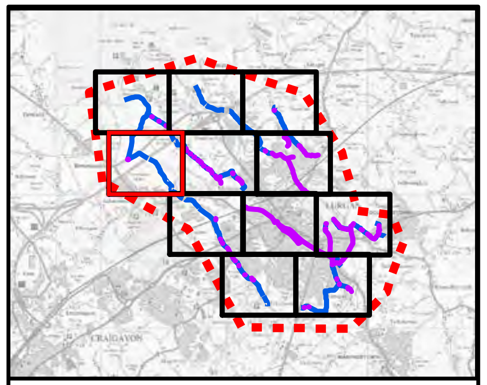
Approved By : G.G. **Date :** 19th February 2018

Drawing No. :

Map Series : Page 3 of 11

Drawing Scale : 1:5,000 @ A3





IMPORTANT USER NOTE:
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Legend

- Salmonid Rivers
- Ancient Woodland
- Area of Specific Scientific Interest (ASSI)
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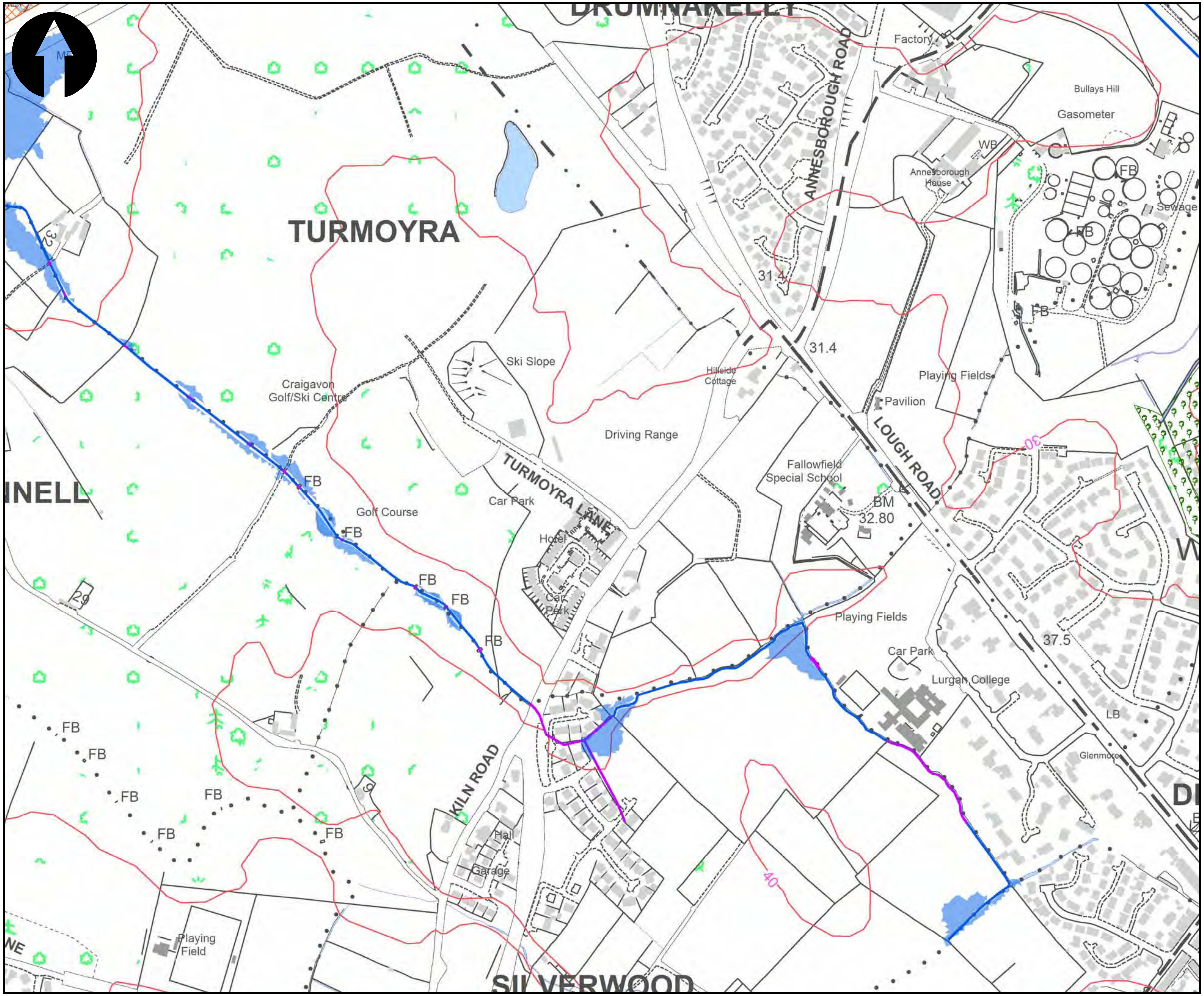
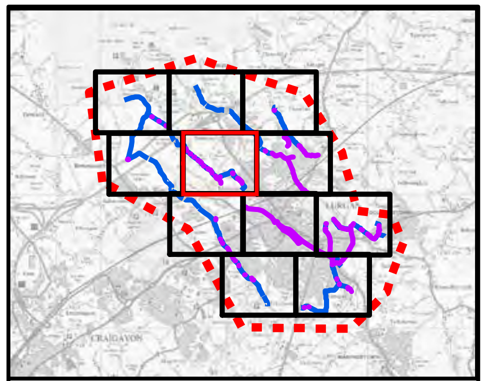
Map:
Portadown Fluvial Environmental Risk Map

Map Type: General Risk - Environmental
Source: Fluvial
Map Area:
Scenario: Current
Drawn By : J.D. Date : 19th February 2018
Checked By : M.W. Date : 19th February 2018
Approved By : G.G. Date : 19th February 2018
Drawing No. :

Map Series : Page 4 of 11

Drawing Scale : 1:5,000 @ A3





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Legend

- Salmonid Rivers
- Ancient Woodland
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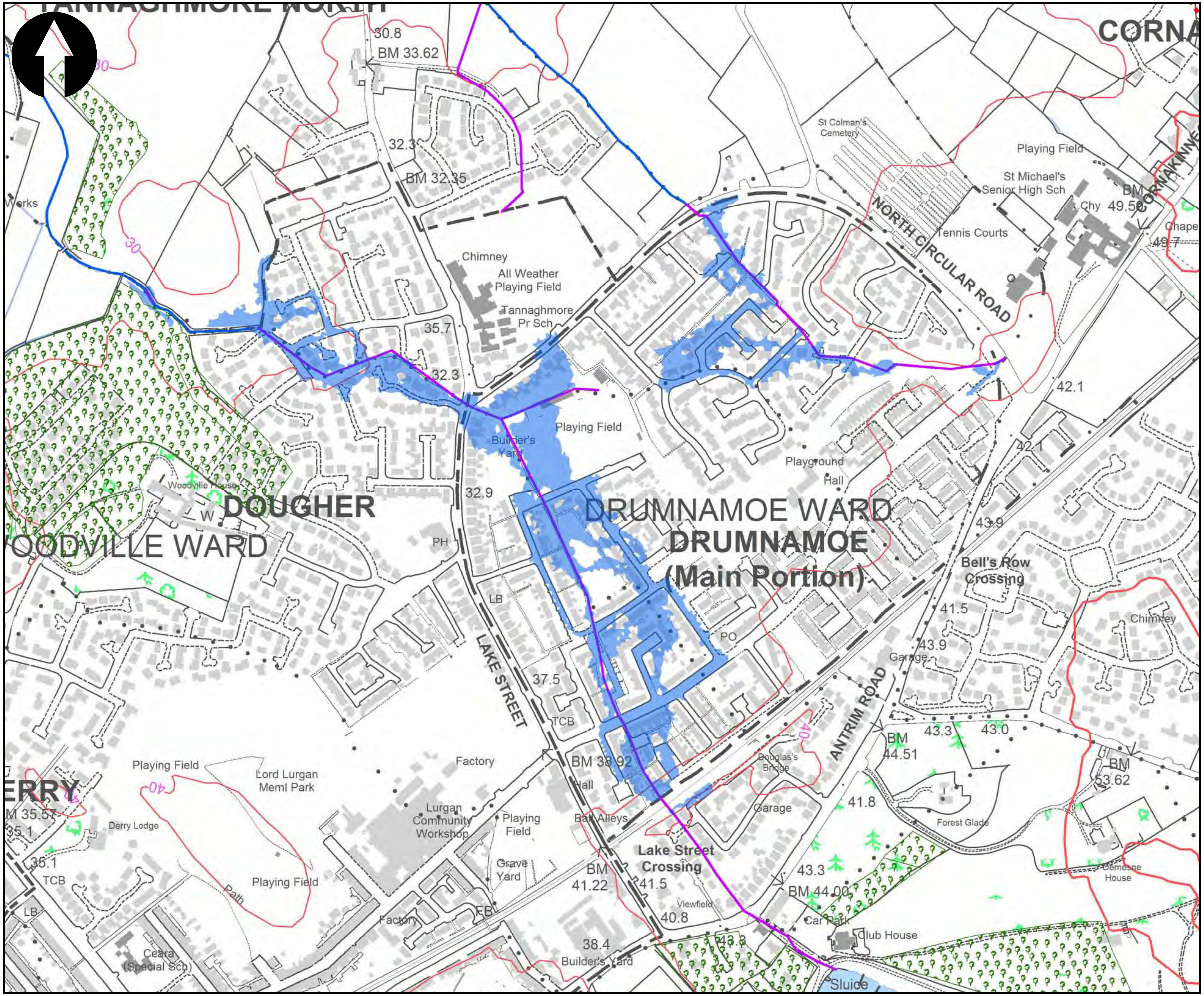
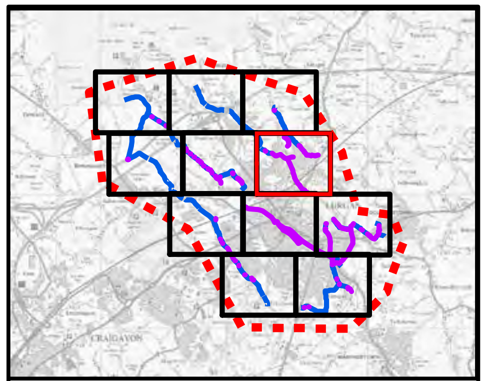
Map:
Portadown Fluvial Environmental Risk Map

Map Type:	General Risk - Environmental	
Source:	Fluvial	
Map Area:		
Scenario:	Current	
Drawn By :	J.D.	Date : 19th February 2018
Checked By :	M.W.	Date : 19th February 2018
Approved By :	G.G.	Date : 19th February 2018
Drawing No. :		
Map Series :	Page 5 of 11	
Drawing Scale :	1:5,000 @ A3	





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Legend

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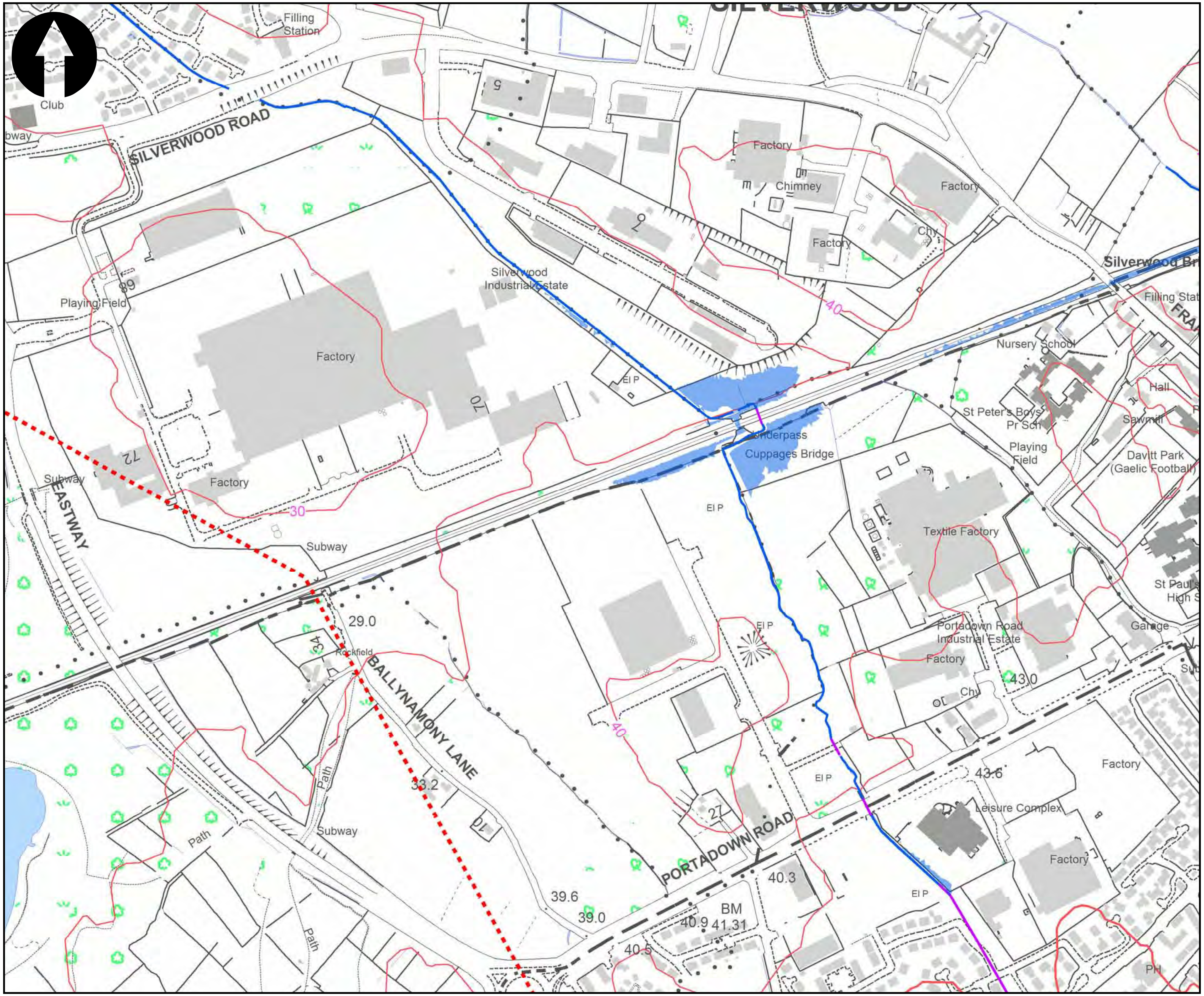
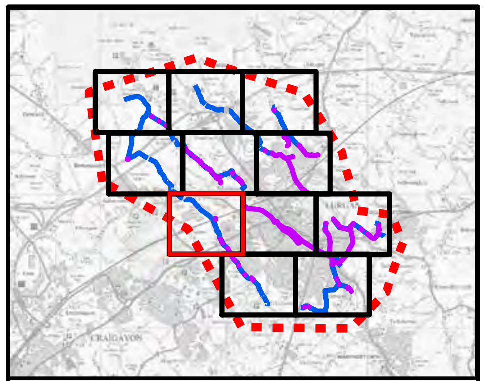
Map: Portadown Fluvial Environmental Risk Map

Map Type:	General Risk - Environmental
Source:	Fluvial
Map Area:	
Scenario:	Current
Drawn By : J.D.	Date : 19th February 2018
Checked By : M.W.	Date : 19th February 2018
Approved By : G.G.	Date : 19th February 2018
Drawing No. :	
Map Series : Page 6 of 11	
Drawing Scale : 1:5,000 @ A3	





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Legend

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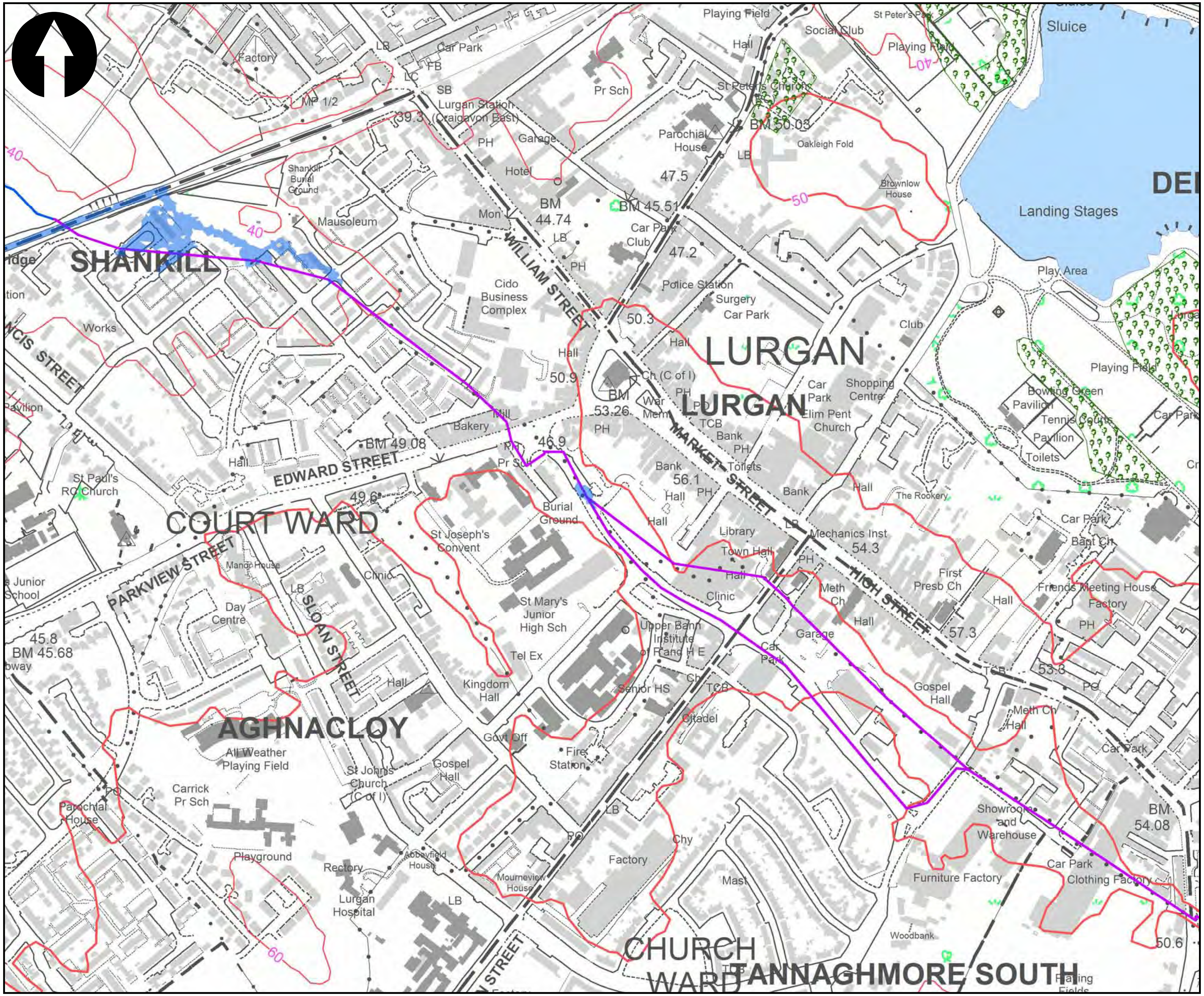
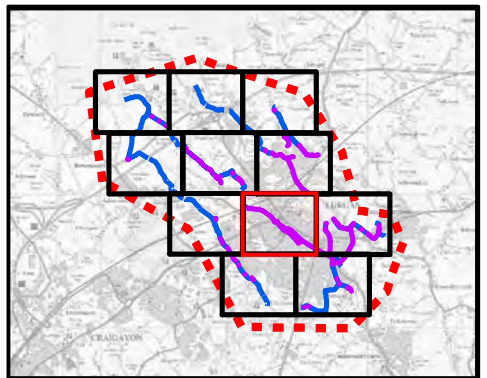
Map:
Portadown Fluvial Environmental Risk Map

Map Type: General Risk - Environmental		
Source: Fluvial		
Map Area:		
Scenario: Current		
Drawn By : J.D.		**Date : 19th February 2018**
Checked By : M.W.		**Date : 19th February 2018**
Approved By : G.G.		**Date : 19th February 2018**
Drawing No. :		
Map Series : Page 7 of 11		
Drawing Scale : 1:5,000 @ A3		





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Legend

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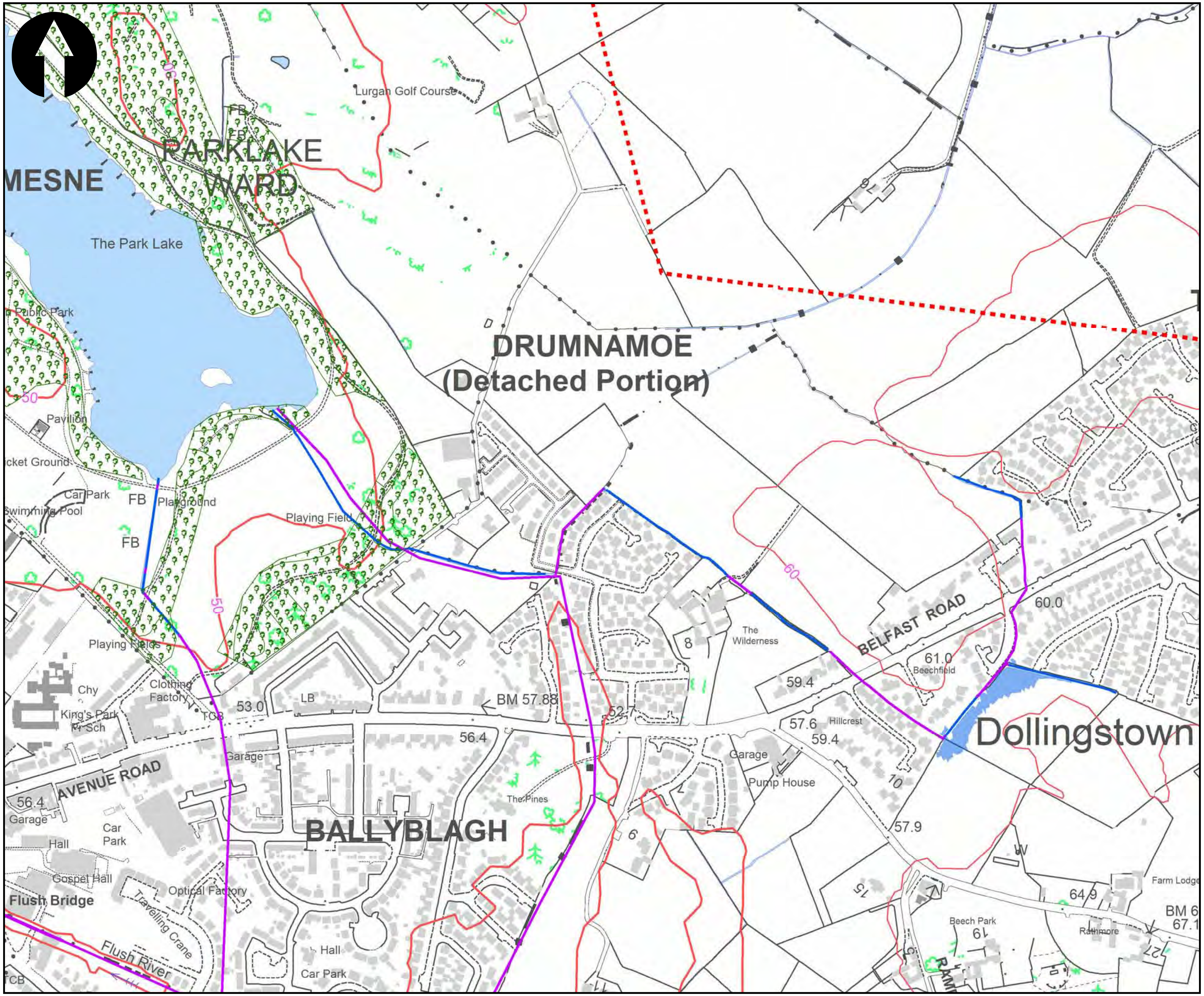
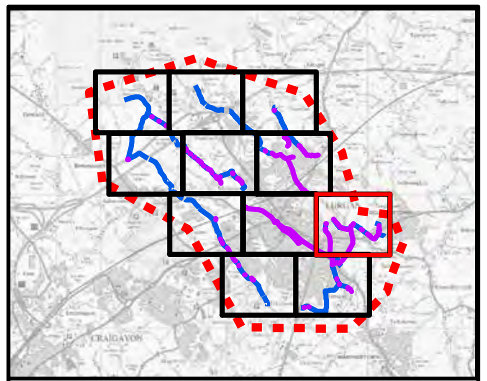
Map:
Portadown Fluvial Environmental Risk Map

Map Type:	General Risk - Environmental
Source:	Fluvial
Map Area:	
Scenario:	Current
Drawn By : J.D.	Date : 19th February 2018
Checked By : M.W.	Date : 19th February 2018
Approved By : G.G.	Date : 19th February 2018
Drawing No. :	
Map Series : Page 8 of 11	
Drawing Scale : 1:5,000 @ A3	





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Legend

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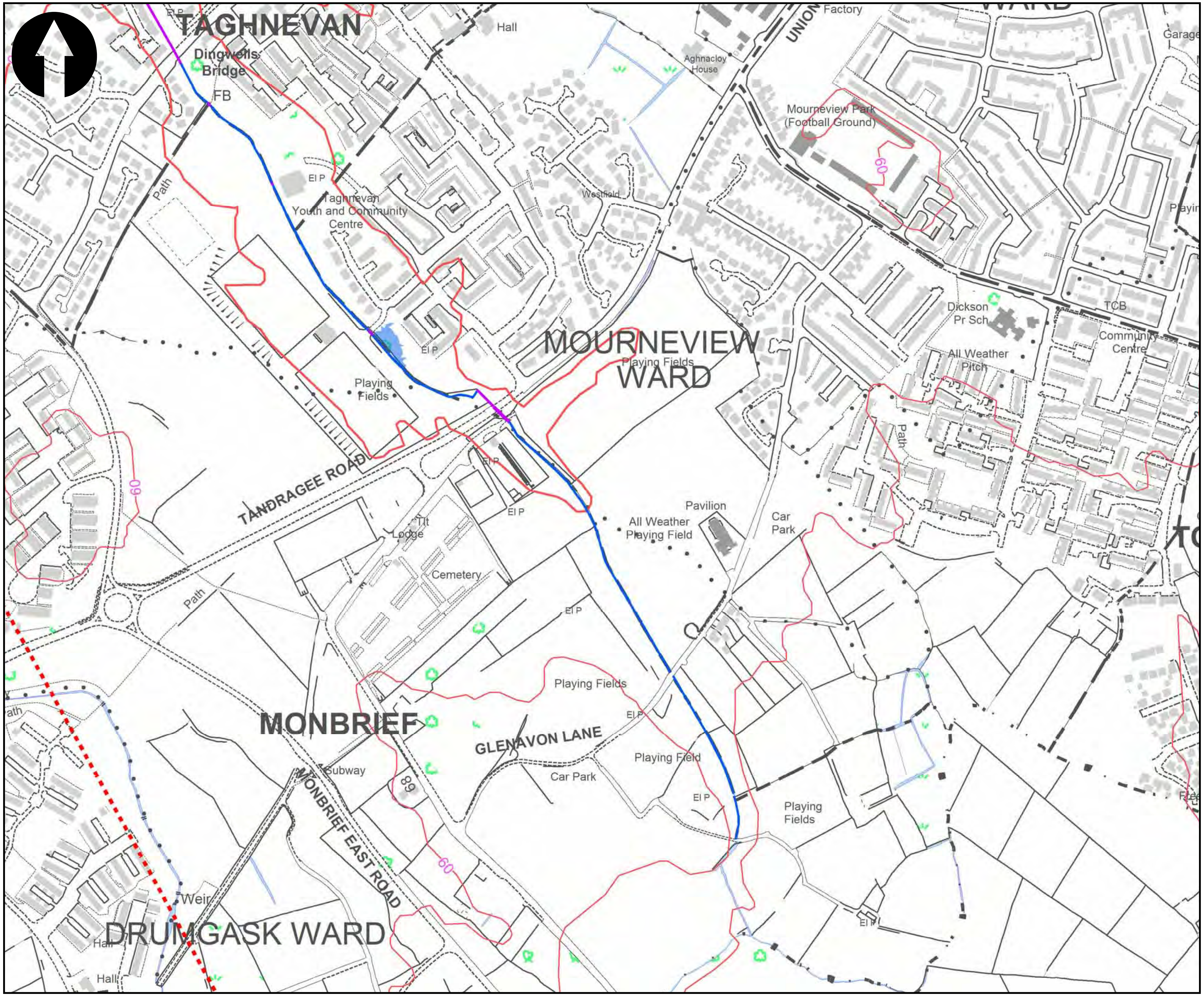
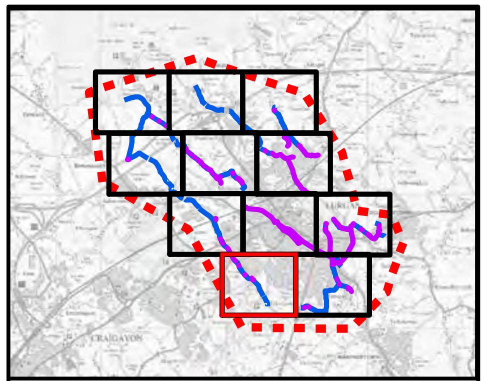
Map:
Portadown Fluvial Environmental Risk Map

Map Type:	**General Risk - Environmental**
Source:	**Fluvial**
Map Area:	
Scenario:	**Current**
Drawn By : J.D.	**Date : 19th February 2018**
Checked By : M.W.	**Date : 19th February 2018**
Approved By : G.G.	**Date : 19th February 2018**
Drawing No. :	
Map Series : Page 9 of 11	
Drawing Scale : 1:5,000 @ A3	





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Legend

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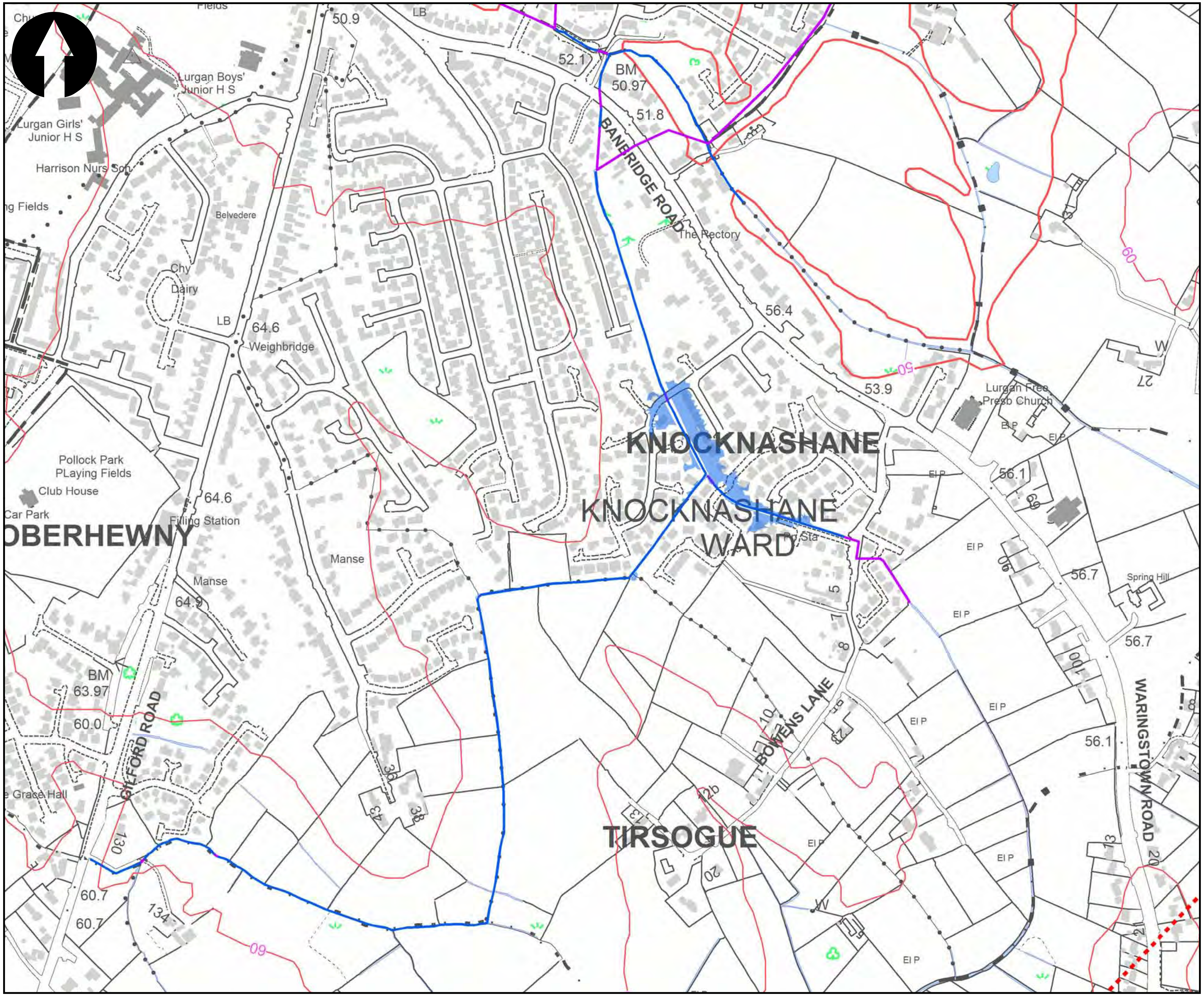
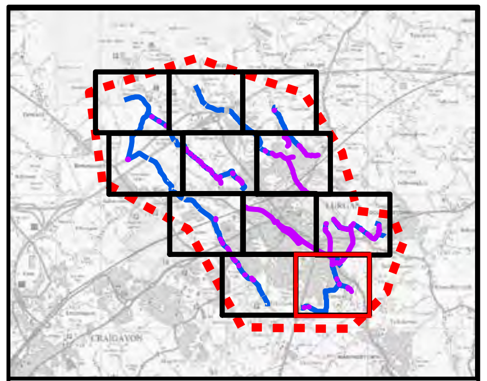
Map:
Portadown Fluvial Environmental Risk Map

Map Type: General Risk - Environmental
Source: Fluvial
Map Area:
Scenario: Current
Drawn By : J.D. Date : 19th February 2018
Checked By : M.W. Date : 19th February 2018
Approved By : G.G. Date : 19th February 2018
Drawing No. :

Map Series : Page 10 of 11

Drawing Scale : 1:5,000 @ A3





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Legend

- Salmonid Rivers
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Map: Portadown Fluvial Environmental Risk Map

Map Type: General Risk - Environmental

Source: Fluvial

Map Area:

Scenario: Current

Drawn By : J.D. Date : 19th February 2018

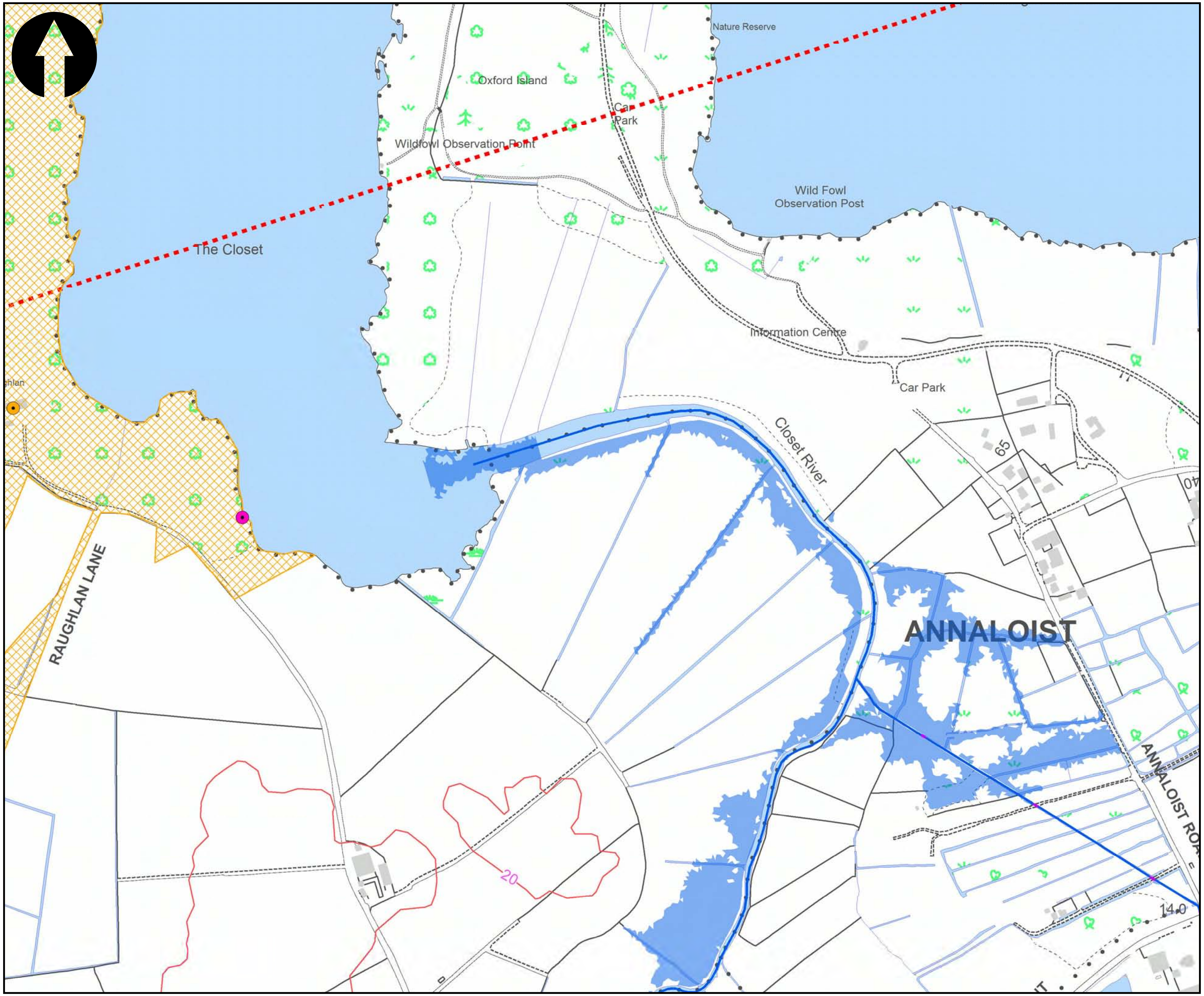
Checked By : M.W. Date : 19th February 2018

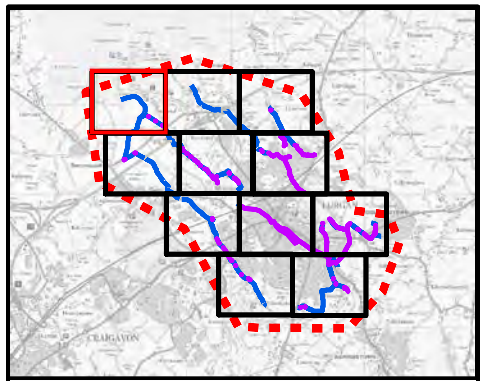
Approved By : G.G. Date : 19th February 2018

Drawing No. :

Map Series : Page 11 of 11

Drawing Scale : 1:5,000 @ A3





IMPORTANT USER NOTE:
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Legend

- Listed Buildings
- Industrial Heritage Buildings

Properties with 1% AEP £ Damage

- Commerical
- Residential

Community Receptors

- Fire Station
- Health Centre
- Police Station
- Residential/Nursing Home
- School
- Historic Parks and Gardens
- Areas of Archeological Potential
- Areas of Special Archeological Interest
- Properties within 1% AEP Flood Extent
- Lurgan Study Area
- 1% AEP Flood Extent
- Conduit
- River Centreline

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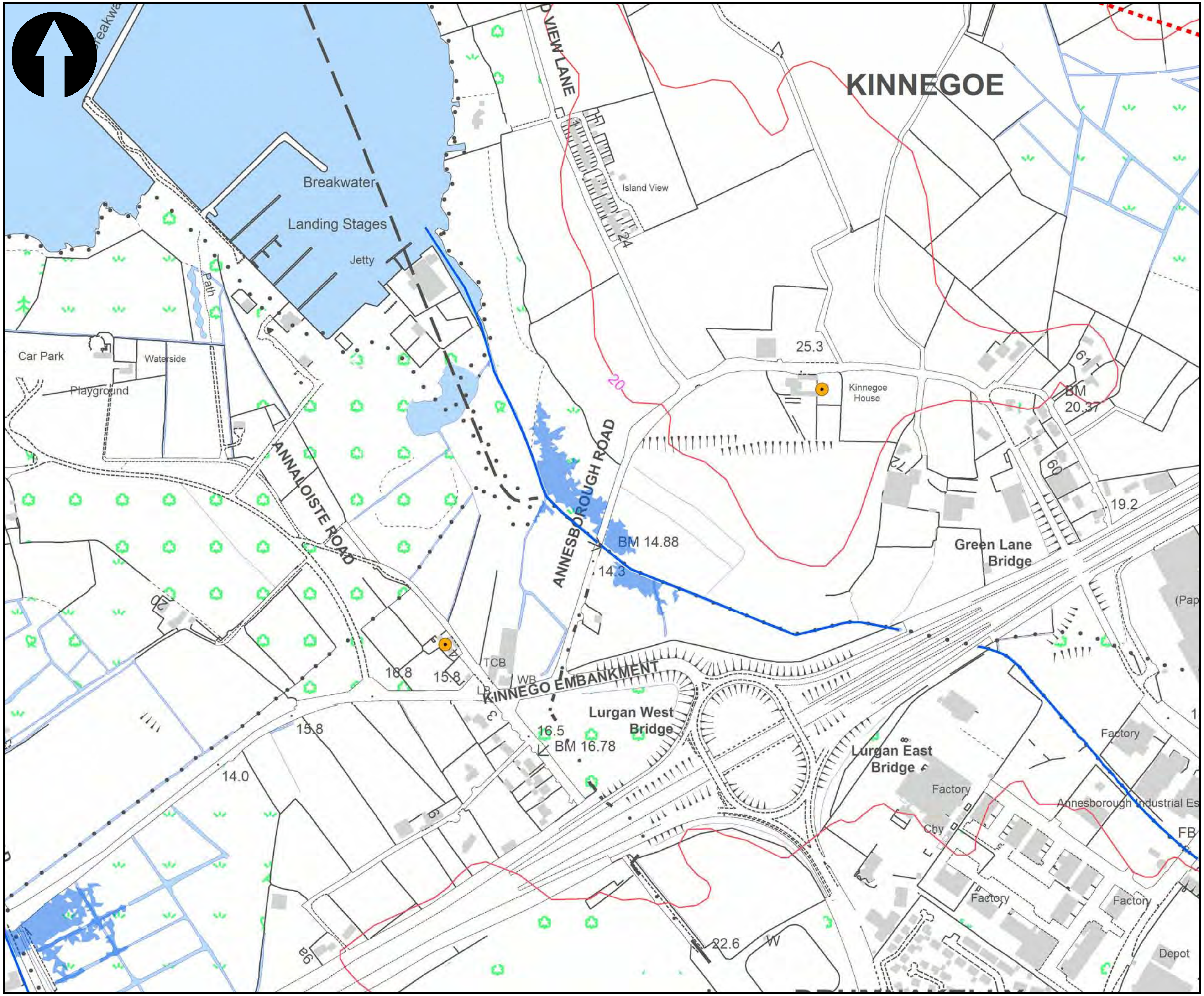
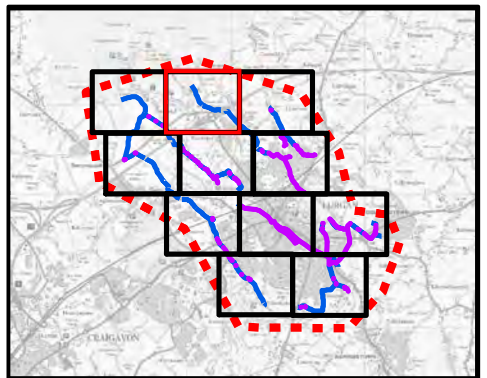
Map:
Lurgan Fluvial Social Risk Map

Map Type: General Risk - Social
Source: Fluvial
Map Area:
Scenario: Current
Drawn By : J.D. **Date :** 13th February 2018
Checked By : M.W. **Date :** 13th February 2018
Approved By : G.G. **Date :** 13th February 2018
Drawing No. :

Map Series : Page 1 of 11
Drawing Scale : 1:5,000 @ A3





IMPORTANT USER NOTE:
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Legend

- Listed Buildings
- Industrial Heritage Buildings

Properties with 1% AEP £ Damage

- Commerical
- Residential

Community Receptors

- Fire Station
- Health Centre
- Police Station
- Residential/Nursing Home
- School
- Historic Parks and Gardens
- Areas of Archeological Potential
- Areas of Special Archeological Interest
- Properties within 1% AEP Flood Extent
- Lurgan Study Area
- 1% AEP Flood Extent
- Conduit
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Map: Lurgan Fluvial Social Risk Map

Map Type:	General Risk - Social
Source:	Fluvial
Map Area:	
Scenario:	Current
Drawn By : J.D.	Date : 13th February 2018
Checked By : M.W.	Date : 13th February 2018
Approved By : G.G.	Date : 13th February 2018
Drawing No. :	

Map Series : Page 2 of 11

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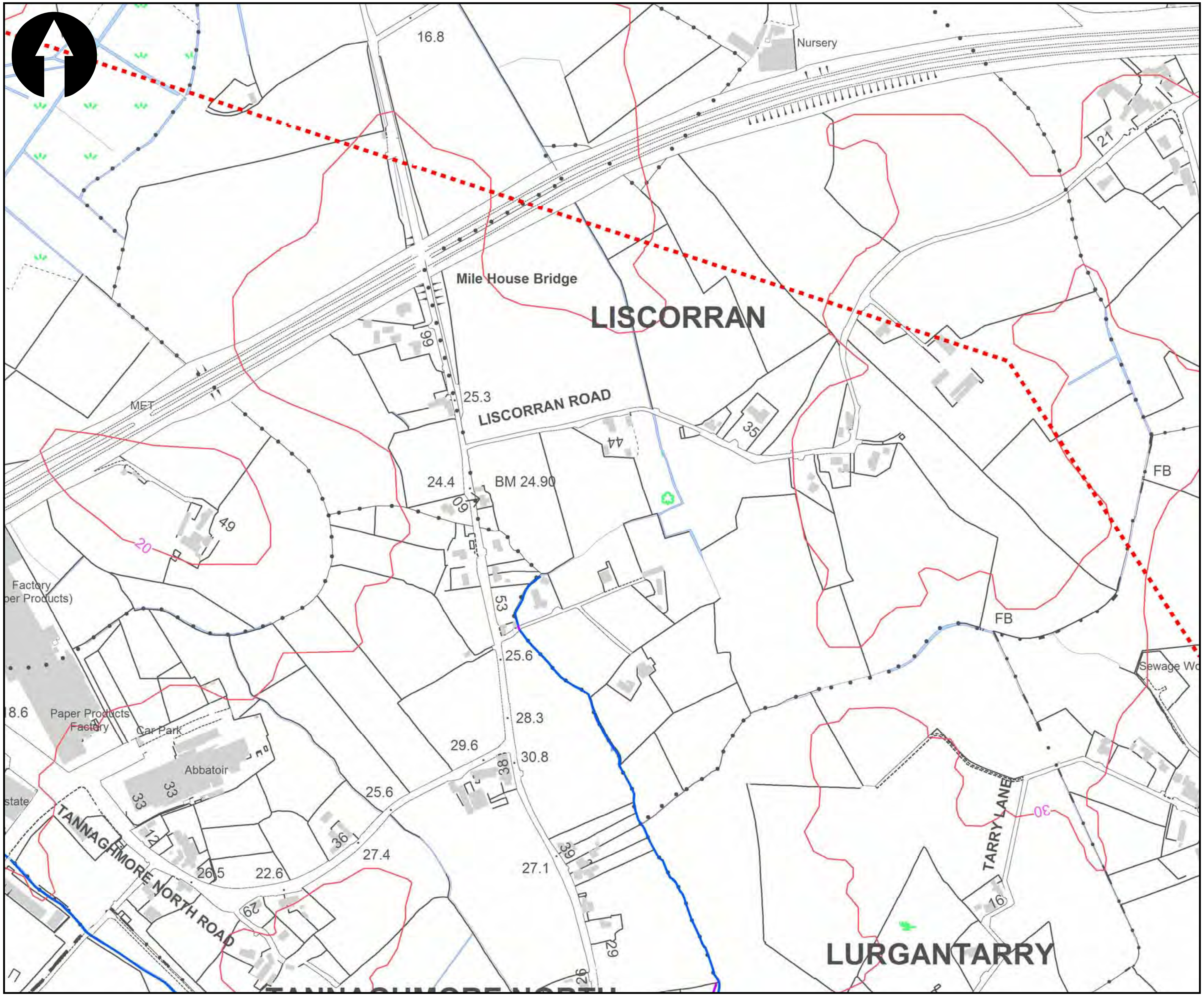

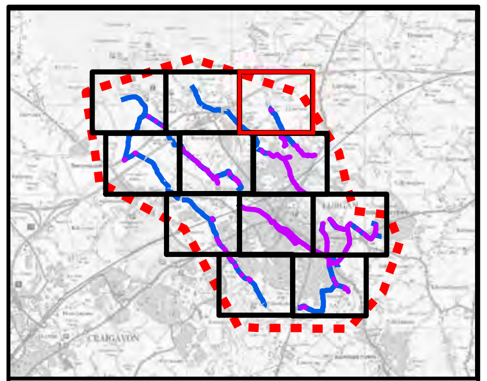

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Map Series : Page 3 of 11

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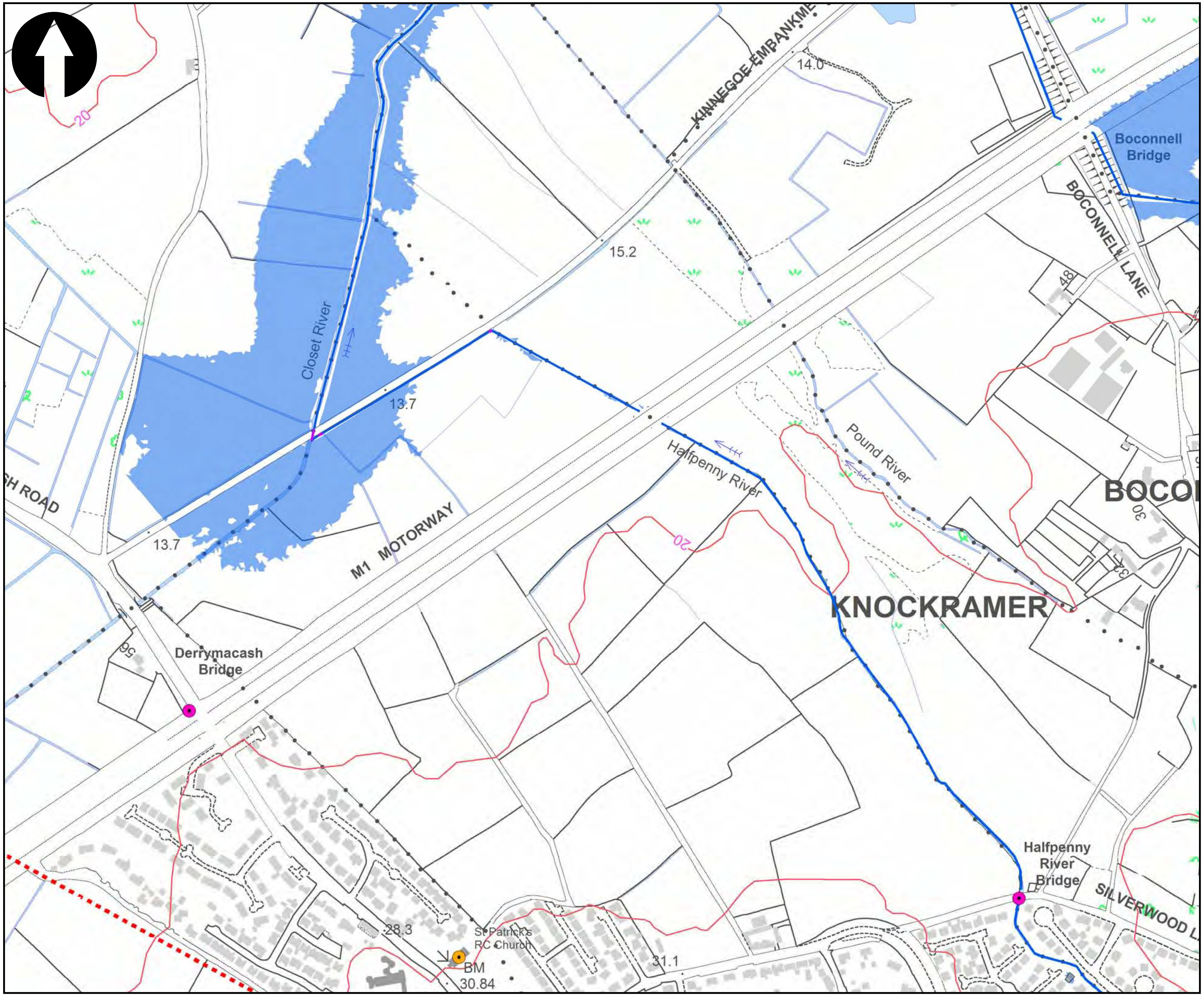

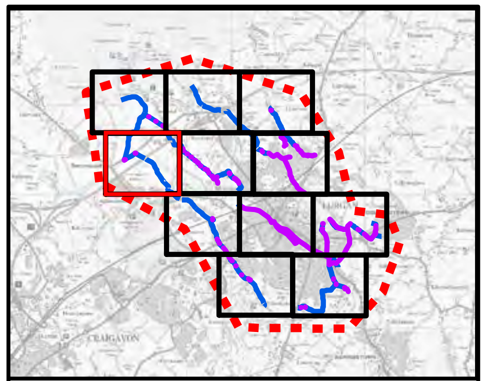

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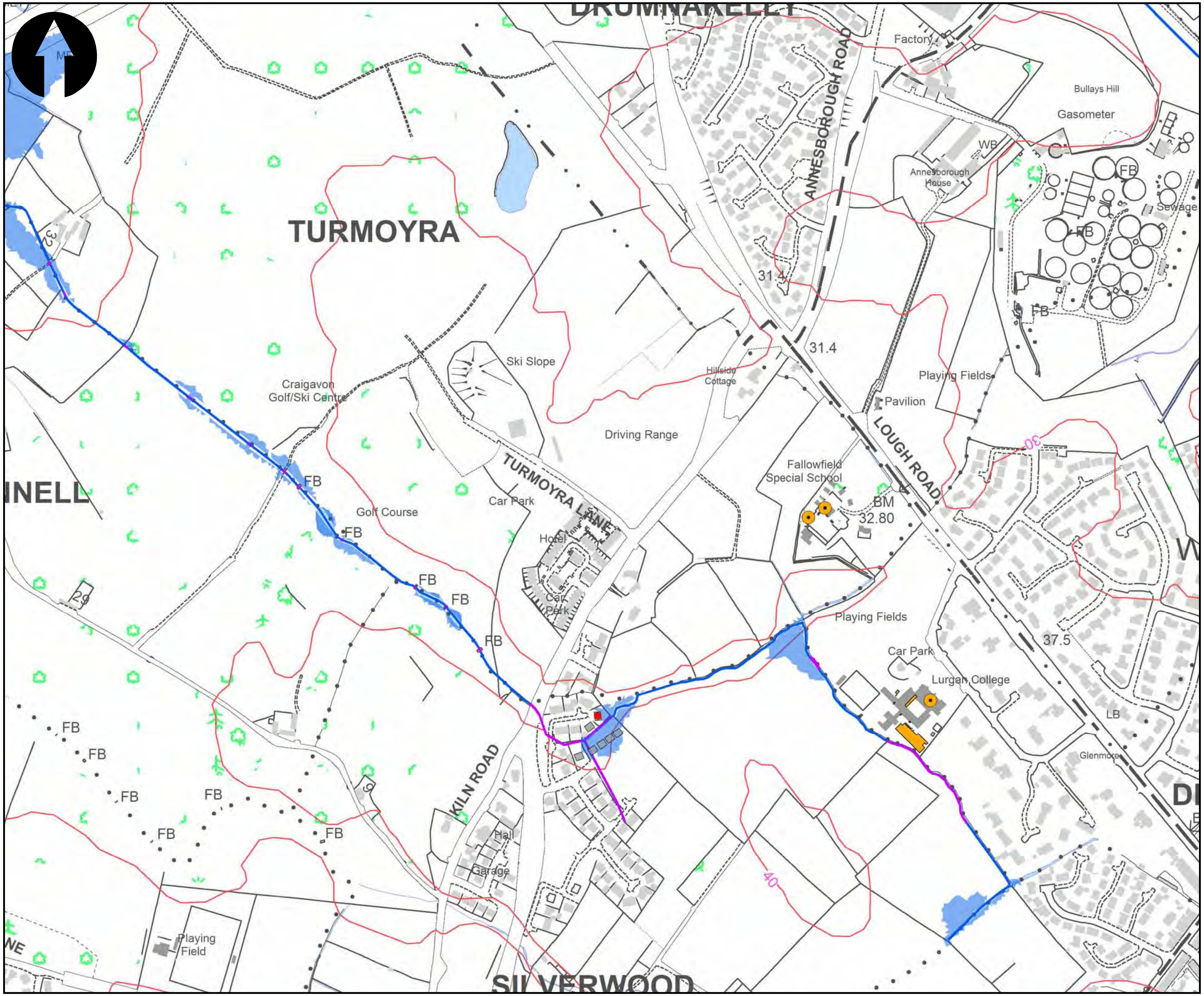

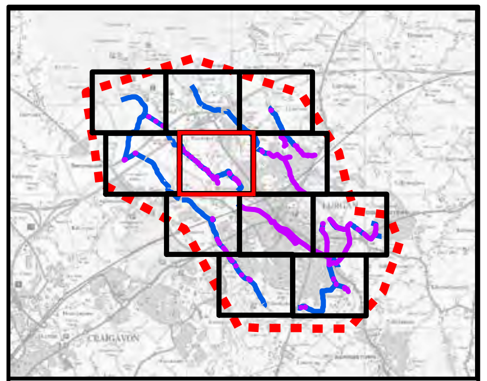

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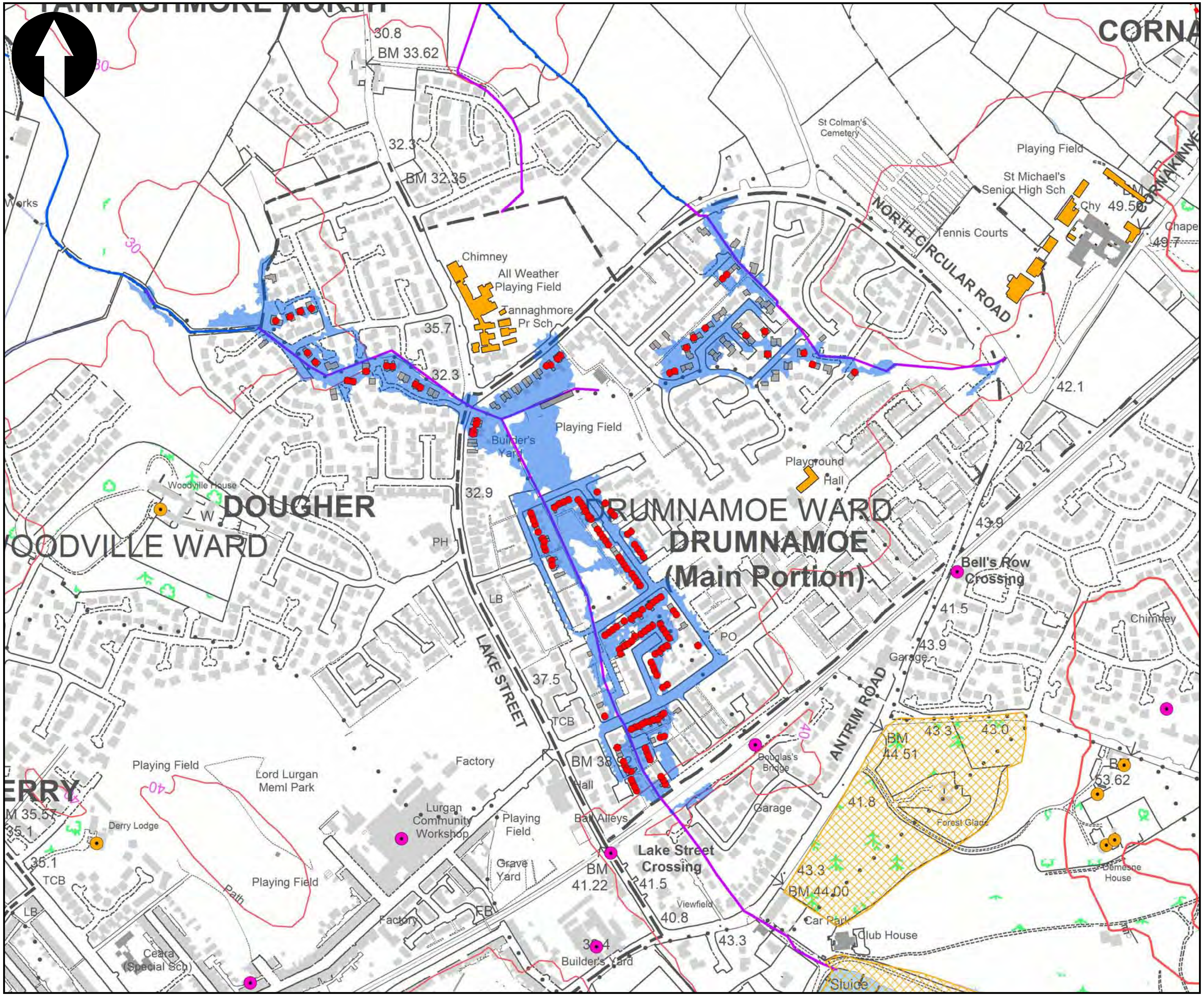

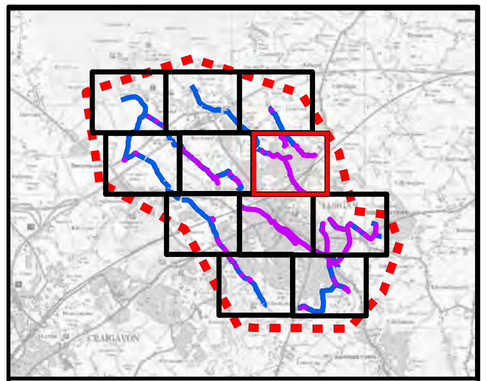

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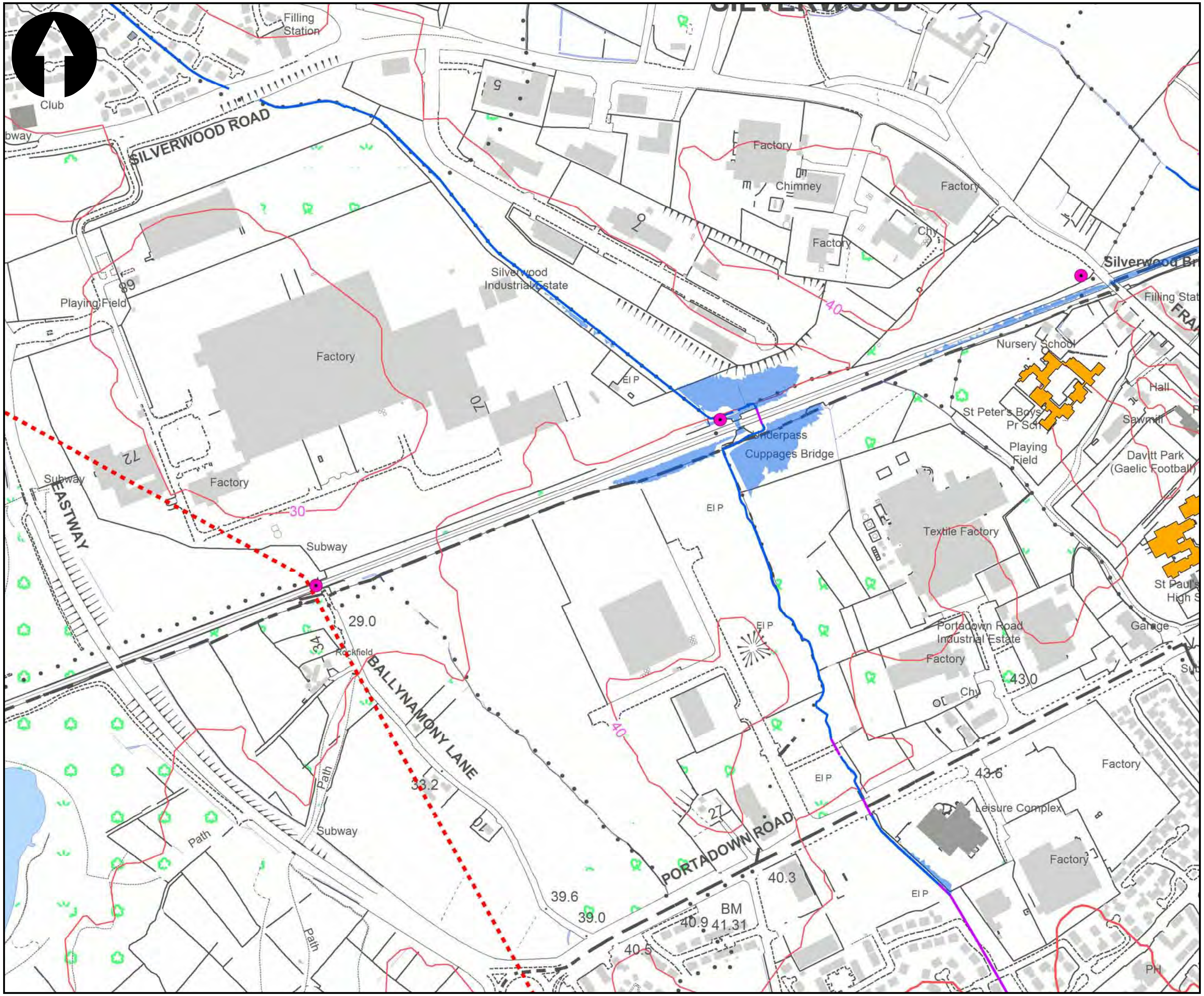

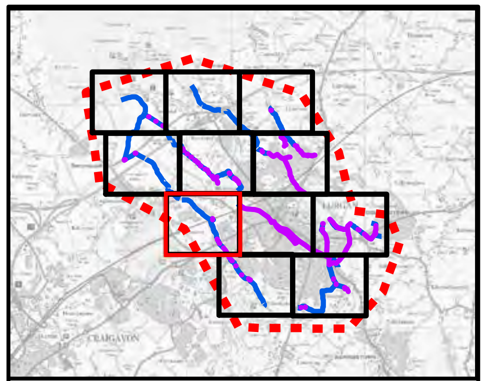

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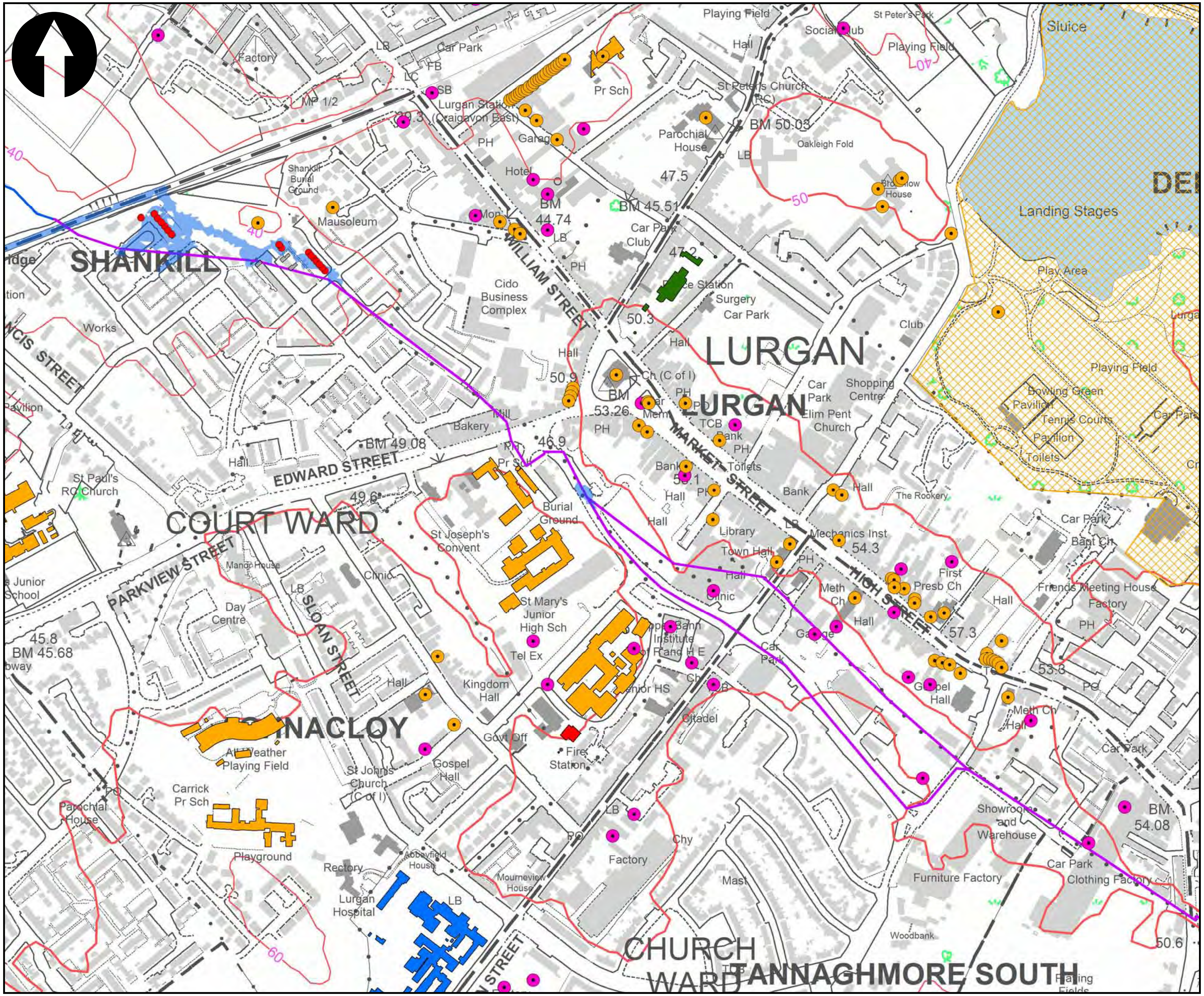

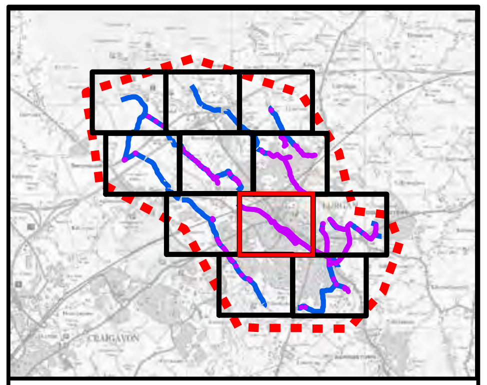

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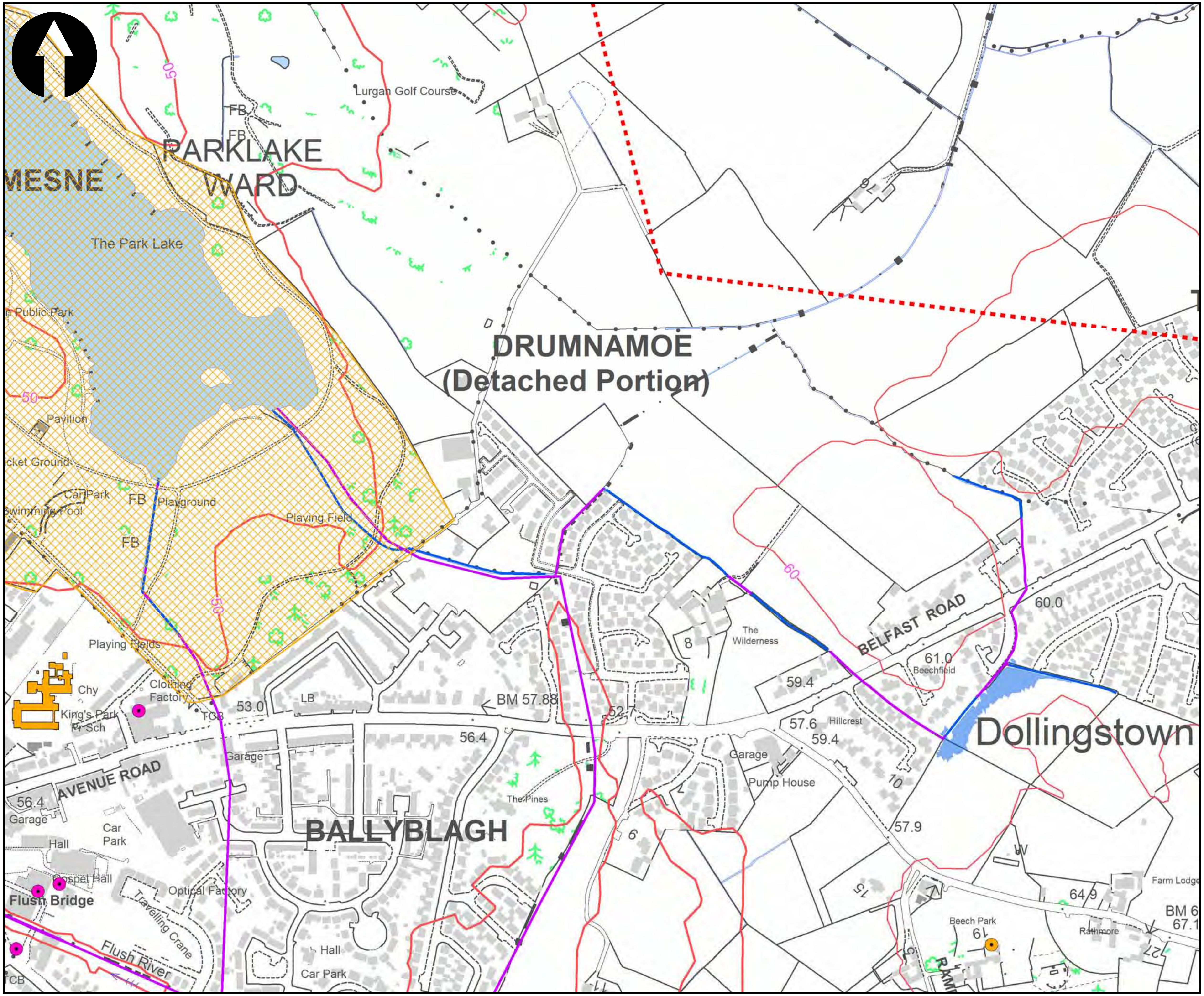

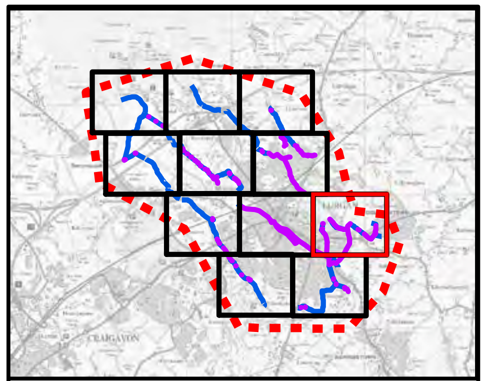

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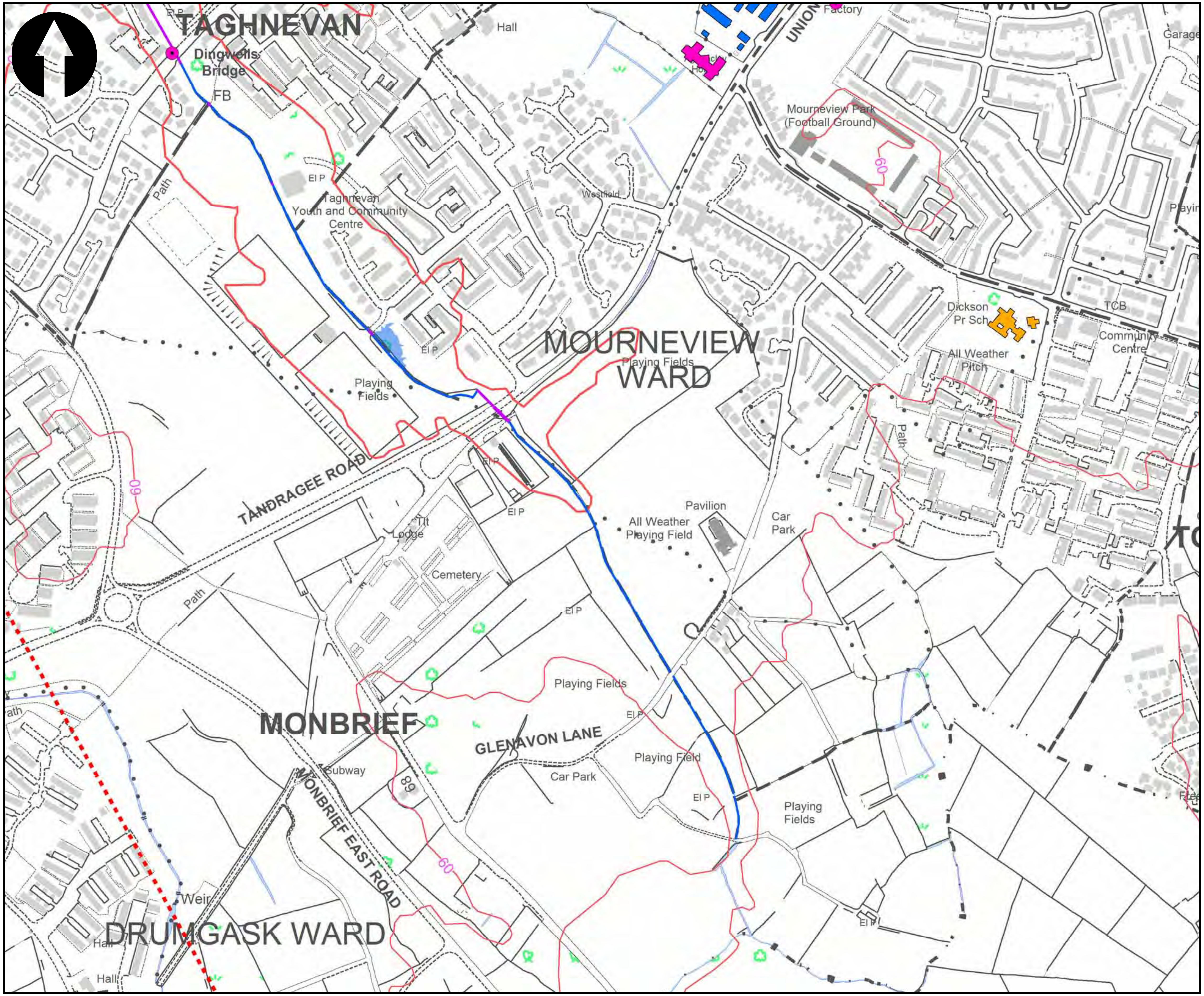

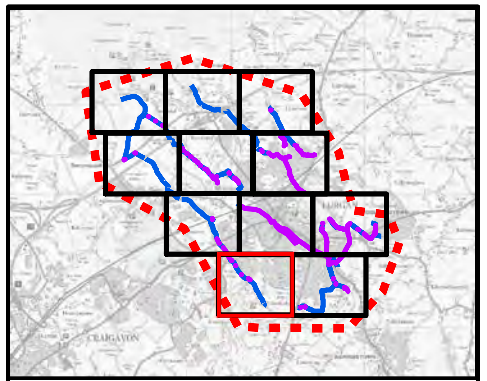

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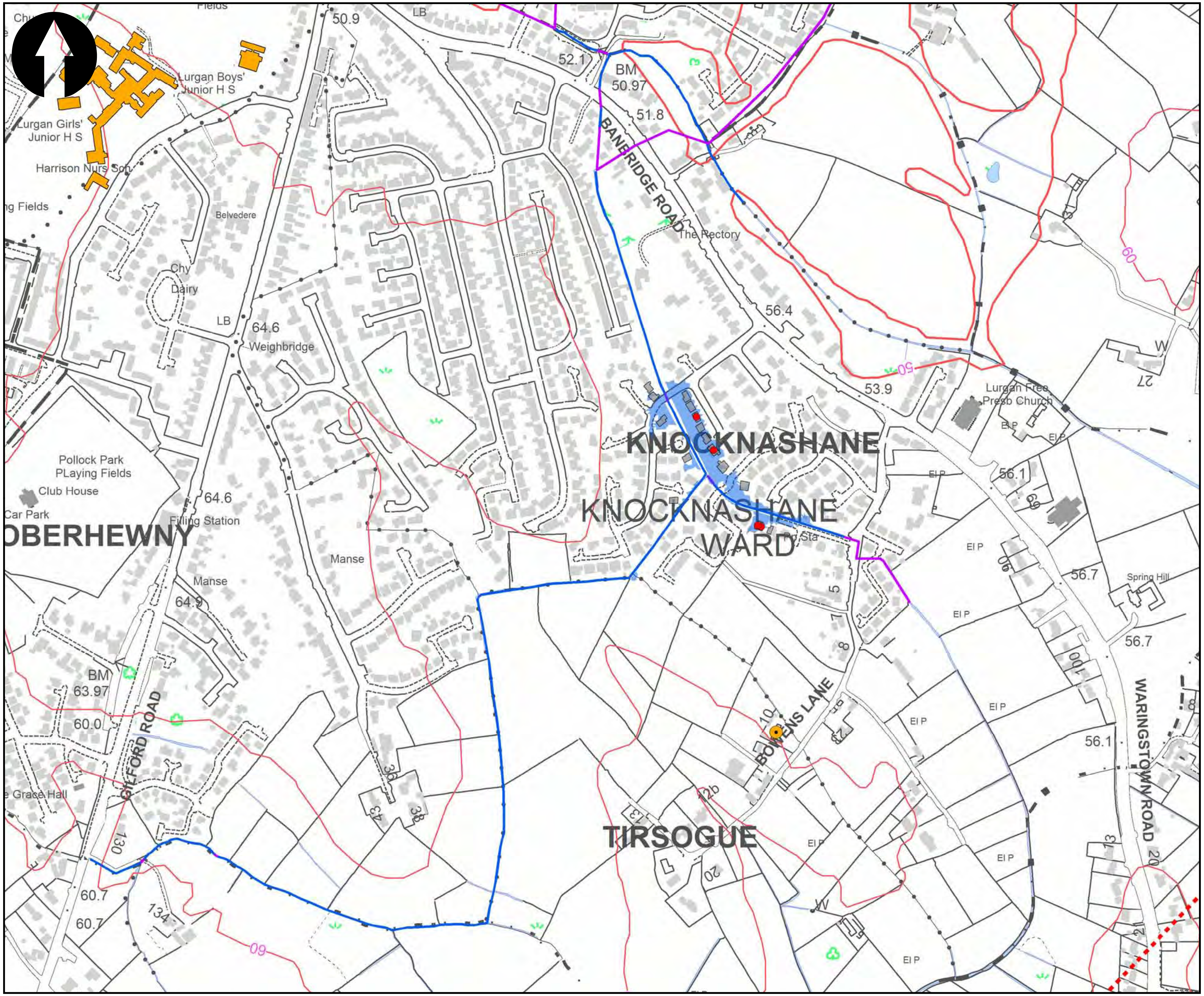

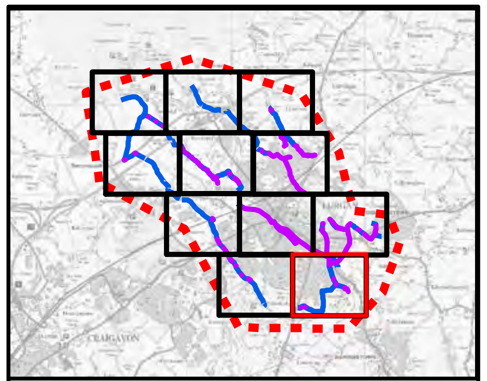

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APPENDIX C

DAMAGE AND DEFENCE COSTS ASSUMPTIONS

COST & DAMAGE ASSUMPTIONS

Assumptions made on maintenance/inspection costs

The maintenance and operational costs have been supplied by DfI Rivers. The annual maintenance costs have been calculated as follows:

Inspections at £405 per day x 0.15 day	£61
Maintenance at £405 per day x 2.5 day	£1,012

The total estimated annual inspection/maintenance cost is therefore £1,073 (approximated to £1,000)

Assumptions made on defence costs

The following assumptions were made in the calculation of the defence costs.

Reinforced concrete walls only:
- Flood wall thickness assumed to be 300mm;
- Base thickness of floodwall assumed to be the same as the stem (300mm);
- Height of the proposed floodwall calculated on the assumption that the top of the base is 1m below GL;
- Base width of floodwall assumed to be base thickness + wall height.

Earth embankment:
- Slope of embankment assumed to be 1:3;
- Assume constructed using impermeable clay material;
- Assume depth below ground level of 4m;
- Width and depth of capping beam assumed to be 800mm.

All:
- An additional 15% has been added to the costs to cover the preliminaries. This include items associated with: Establishment of the site; Insurance, permits, paperwork, etc.; Site running costs; Handover of site; Supervision, labourers, etc.; and Overheads or others costs;
- An additional 10% has been added for fees and contingencies. This cost is included to cover consultancy and design fees and an allowance for the unknown risk associated with a project.
- The lifespan of the scheme is assumed to be 100 years;
- Maintenance costs have been included at £2,000 per year and £5,000 every 5 years for flood defences.

The following rates have been used (2016):

Item	Assumption	Rate	Unit
Clearance - vegetation killing		£230	ha
Clearance - site clearance & disposal	Allowance for tree, plant & scrub removal	£5	m^2
Excavation - topsoil strip &stockpile	Assumed 300mm depth	£3	m^2
Provision & placing of concrete	Assumed Grade 40	£110	m^3
Reinforcement (provision & fix)	Assumed 1t per 9m^3 of reinforced concrete	£900	t
Trenchfill (Grade C20)	Allowance made for 1m depth (throughout length & width)	£75	m^3
Formwork (plain)		£50	m^2
Formwork (moulded feature)		£75	m^2
Granite finish to wall		£80	m^2
Filling - provision of topsoil		£16	m^3
Filling - topsoil	Assumed 300mm depth	£8.50	m^3
Finishing- grassing out		£1.05	m^2
Filling - provision of clay fill		£25	m^3
Filling - clay fill		£8.50	m^3
Geotextile mat		£3	m^2
Drainage		£35	m
Concrete pipes with rebated flexible joints to BS 5911 Class 120	900mm in trenches depth: up to 1.50m 1.50-2.00m 2.50-3.00m 3.50-4.00m 1200mm in trenches depth: up to 1.50-2.00m 2.00-2.50m 2.50-3.00m 3.00-3.50m	£182.42 £195.71 £220.33 £294.22 £311.95 £325.18 £344.16 £372.56	m m m m m m m m
Concrete pipes – extra for bends	750mm 900mm 1200mm	£984.03 £1338.63 £2255.23	- - -
Manhole – precast concrete construction	Circular shafts; 1200 dia. x 1500 depth to invert 1200 dia. x 2000 depth to invert 1200 dia. x 3000 depth to invert 1800 dia. x 4000 depth to invert	£1444.28 £1532.10 £2202.36 £5110.14	- - - -
Sealed Manholes	Replace depth: 1.00-1.50m up to 3m	£6755.40 £12780.50	- -
Inlet/Outlet Headwall and Screen		£10,820.00	
Flap Valve	900mm 1200mm	£1,799.31 £3,082.84	- -
Weir	2m high, 20m long	£74,681.08	-
Excavation for cuttings	Max depth 3.5m	£11.03	m^3

Road reinstatement		**£229.07**	**m**
	Cold milling	£1.50	m^2
	Resurfacing surface course	£11.00	m^2
	Binder course cold milling	£2.00	m^2
	Binder course	£8.00	m^2
	Base course	£10.00	m^2
	Concrete surround/backfill	£100.00	m^3
	Misc. (road markings)	£8.60	m

Assumptions made on Damage Assessment

The following assumptions and methods were used in the damage assessment:

- The damage assessment follows the MCM guidance;
- Finished floor levels of properties were taken to be 300mm above ground level;
- The average flood depth for any given event was taken at the centre of the property;
- Damage values were based on the MCM 2016 data;
- Intangible benefits were assumed and were calculated according to DEFRA Flood and Coastal Defence Project Appraisal Guidance (FCDPAG3), Economic Appraisal Supplementary Note to Operating Authorities, Revisions to Economic Appraisal on: Reflecting socio-economic equity in appraisal and Appraisal of human related intangible impacts of flooding;
- Damage values to houses and commercial properties were capped at their market value according to data supplied from Land & Property Services.

APPENDIX D

CONSTRUCTION COSTS

Flood Cell 1 and Flood Cell 2: Upstream Storage

	Rate	Units	Quantity	Cost	Quantity	Cost
Embankment			FID 0		FID 1	
Height of embankment		m	1.00		0.85	
Crest Width		m	3.00		3.00	
Base width		m	8.98		8.10	
Core		m2	11.16		9.45	
Topsoil		m2	0.57		0.48	
Geotextile		m	8.67		7.74	
Length of section		m	30.00		30.00	
Main Elements						
Clearance - Vegetation killing	£230.00	ha	0.03	£6.19	0.02	£5.59
Clearance - Site clearance & disposal	£5.00	m2	269.28	£1,346.40	243.00	£1,215.00
Excavation - Topsoil strip & stockpile	£3.00	m2	269.28	£807.84	243.00	£729.00
Filling - Provision of topsoil	£16.00	m3	17.03	£272.45	14.40	£230.40
Filling - Topsoil (300mm depth)	£8.50	m3	17.03	£144.74	14.40	£122.40
Filling - Provision of clay fill	£25.00	m3	334.69	£8,367.33	283.50	£7,087.52
Filling - Placing of clay fill	£8.50	m3	334.69	£2,844.89	283.50	£2,409.76
Geotextile mat	£3.00	m2	260.00	£780.01	232.30	£696.91
Finishing - Grassing out	£1.05	m2	160.91	£168.95	137.32	£144.19
Drainage	£35.00	m	30.00	£1,050.00	30.00	£1,050.00
Additional Work		Sum		£1,000.00		£1,000.00
Sub-Total				£16,788.80		£14,690.76
Preliminaries				2518.320176		2203.61432
TOTAL				£19,307.12		£16,894.38

Total Embankment Cost £36,201.50

Culvert

Width of Embankment	Pipe Diameter	Trench Depth	Price/m	Cost	Inlets/Outlets	Inlet/Outlet Headwall + Screen
11.16	400	1.9	£78.42	£875.17	2	£10,820.00
						£21,640.00

Sub Total	£22,515.17
Pelimainaries	£3,377.28
Total Cost	£25,892.44

Storage Weir Structure

From CFRAMS

	Length (m)	Total Cost
Weir 2m high	10	48632.286

Adjustment Factor

0.912891643

Total Cost £44,396.01

Land Acquisition

Area (acres)	Cost/acre
13.44	£10,000.00

Total Cost £134,400.00

Total Cost of Storage for FC1 £240,889.95

Flood Cell 3: Hard Defences - Walls

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 1 - FID 4		Wall 2 - FID 75		Wall 3 - FID 76		Wall 4 - FID 77	
Wall thickness		m	0.30		0.30		0.30		0.3	
Base thickness		m	0.30		0.30		0.30		0.3	
Wall height		m	0.39		0.71		0.80		0.65	
Base width		m	0.69		1.01		1.10		0.95	
Length of section		m	9.95		9.95		9.95		9.95	
Main Elements										
Clearance - Vegetation killing	£230.00	ha	0.001	£0.16	0.001	£0.23	0.001	£0.25	0.00	£0.22
Clearance - Site clearance & disposal	£5.00	m2	6.915	£34.57	9.999	£49.99	10.924	£54.62	9.43	£47.16
Excavation - Topsoil strip & stockpile	£3.00	m2	6.915	£20.74	9.999	£30.00	10.924	£32.77	9.43	£28.29
Base Slab - Provision & placing of concrete	£110.00	m3	2.074	£228.18	3.000	£329.96	3.277	£360.49	2.83	£311.24
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.230	£207.44	0.333	£299.96	0.364	£327.72	0.31	£282.95
Base Slab - Trenchfill (Grade C20)	£75.00	m3	6.915	£518.59	9.999	£749.91	10.924	£819.30	9.43	£707.37
Base Slab - Formwork	£50.00	m2	5.969	£298.47	5.969	£298.47	5.969	£298.47	5.97	£298.47
Wall - Provision & placing of concrete	£110.00	m3	0.284	£31.19	1.209	£132.97	1.486	£163.50	1.04	£114.25
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.032	£28.35	0.134	£120.88	0.165	£148.64	0.12	£103.87
Wall - Formwork (textured on one side)	£75.00	m2	1.890	£141.77	8.059	£604.40	9.909	£743.19	6.92	£519.34
Wall- Granite finish	£80.00	m2	-6.019	£0.00	-2.935	£0.00	0.000	£0.00	0.00	£0.00
Drainage	£35.00	m	9.949	£348.22	9.949	£348.22	9.949	£348.22	9.95	£348.22
Traffic Management		Sum								
Additional Work										
Sub-total				£1,857.68		£2,964.99		£3,297.17		£2,761.38
Preliminaries				£278.65		£444.75		£494.58		£414.21
TOTAL				£2,136.34		£3,409.73		£3,791.75		£3,175.59

Total Cost of Walls for FC3 £12,513.41

Flood Cell 4: Seal Manholes

Number of Manholes	Cost
10	£67,554.00
2	£25,561.00
Sub-total	£93,115.00
Preliminaries	£13,967.25
Total	£107,082.25

Flood Cell 5: Seal Manholes

Number of Manholes	Cost
10	£67,554.00
8	£102,244.00
Sub-total	£169,798.00
Preliminaries	£25,469.70
Total	£195,267.70

Summary

Flood Cell 1 Storage	£240,889.95
Flood Cell 3 Hard Defences - Walls	£12,513.41
Flood Cell 4 - Sealing Manholes	£107,082.25
Flood Cell 5 - Sealing Manholes	£195,267.70
Sub-Total	£555,753.30
Fees & Contingencies (10%)	£55,575.33
Total Option 2 Cost	£611,328.63

Flood Cell 1 Hard Defences: Walls

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 1 - FID 0		Wall 2 - FID 5		Wall 3 - FID 6		Wall 4 - FID 7		Wall 5 - FID 8	
Wall thickness		m	0.30		0.30		0.30		0.3		0.3	
Base thickness		m	0.30		0.30		0.30		0.3		0.3	
Wall height		m	0.61		0.72		0.81		0.88		0.63	
Base width		m	0.91		1.02		1.11		1.18		0.93	
Length of section		m	10.05		10.05		10.05		10.05		10.05	
Main Elements												
Clearance - Vegetation killing	£230.00	ha	0.001	£0.21	0.001	£0.24	0.001	£0.26	0.001	0.27	0.001	0.22
Clearance - Site clearance & disposal	£5.00	m2	9.174	£45.87	10.279	£51.40	11.113	£55.57	11.87	59.33	9.36	46.82
Excavation - Topsoil strip & stockpile	£3.00	m2	9.174	£27.52	10.279	£30.84	11.113	£33.34	11.87	35.60	9.36	28.09
Base Slab - Provision & placing of concrete	£110.00	m3	2.752	£302.74	3.084	£339.21	3.334	£366.73	3.56	391.60	2.81	309.04
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.306	£275.21	0.343	£308.37	0.370	£333.39	0.40	356.00	0.31	280.94
Base Slab - Trenchfill (Grade C20)	£75.00	m3	9.174	£688.04	10.279	£770.93	11.113	£833.48	11.87	890.00	9.36	702.36
Base Slab - Formwork	£50.00	m2	6.029	£301.44	6.029	£301.44	6.029	£301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	£110.00	m3	0.944	£103.79	1.275	£140.26	1.525	£167.78	1.75	192.65	1.00	110.09
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.105	£94.35	0.142	£127.51	0.169	£152.53	0.19	175.14	0.11	100.08
Wall - Formwork (textured on one side)	£75.00	m2	6.290	£471.75	8.501	£637.55	10.169	£762.64	11.68	875.68	6.67	500.39
Wall- Granite finish	£80.00	m2	-3.889	£0.00	-2.783	£0.00	-1.949	-£155.94	-1.20	0.00	-3.70	0.00
Drainage	£35.00	m	10.048	£351.68	10.048	£351.68	10.048	£351.68	10.05	351.68	10.05	351.68
Traffic Management		Sum										
Additional Work												
Sub-total				£2,662.60		£3,059.42		£3,202.89		3629.39		2731.14
Preliminaries				£399.39		£458.91		£480.43		544.41		409.67
TOTAL				£3,061.99		£3,518.33		£3,683.33		£4,173.80		£3,140.82

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 6 - FID 9		Wall 7 - FID 10		Wall 8 - FID 11		Wall 9 - FID 12		Wall 10 - FID 13	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	0.98		0.51		0.62		0.99		0.85	
Base width	1.28		0.81		0.92		1.29		1.15	
Length of section	10.05		10.05		10.05		10.05		10.05	
Main Elements										
Clearance - Vegetation killing	0.001	0.30	0.00	0.19	0.00	0.21	0.00	0.30	0.00	0.27
Clearance - Site clearance & disposal	12.89	64.46	8.18	40.90	9.20	46.02	12.91	64.56	11.55	57.73
Excavation - Topsoil strip & stockpile	12.89	38.67	8.18	24.54	9.20	27.61	12.91	38.74	11.55	34.64
Base Slab - Provision & placing of concrete	3.87	425.42	2.45	269.91	2.76	303.73	3.87	426.09	3.46	380.99
Base Slab - Reinforcement (Provision & Fix)	0.43	386.75	0.27	245.37	0.31	276.12	0.43	387.35	0.38	346.35
Base Slab - Trenchfill (Grade C20)	12.89	966.87	8.18	613.43	9.20	690.30	12.91	968.38	11.55	865.89
Base Slab - Formwork	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	2.06	226.47	0.65	70.96	0.95	104.78	2.06	227.14	1.65	182.04
Wall - Reinforcement (Provision & Fix)	0.23	205.88	0.07	64.51	0.11	95.25	0.23	206.49	0.18	165.49
Wall - Formwork (textured on one side)	13.73	1029.42	4.30	322.54	6.35	476.27	13.77	1032.44	11.03	827.45
Wall- Granite finish	-0.17	0.00	-4.88	0.00	-3.86	0.00	-0.15	0.00	-1.52	0.00
Drainage	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management										
Additional Work										
Sub-total		3997.36		2305.45		2673.42		4004.58		3513.96
Preliminaries		599.60		345.82		401.01		600.69		527.09
TOTAL		£4,596.97		£2,651.27		£3,074.43		£4,605.27		£4,041.05

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 11 - FID 14		Wall 12 - FID 15		Wall 13 - FID 16		Wall 14 - FID 17		Wall 15 - FID 18	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	0.92		0.95		0.82		0.62		0.57	
Base width	1.22		1.25		1.12		0.92		0.87	
Length of section	10.05		10.05		10.05		10.05		10.05	
Main Elements										
Clearance - Vegetation killing	0.00	0.28	0.00	0.29	0.00	0.26	0.00	0.21	0.00	0.20
Clearance - Site clearance & disposal	12.26	61.29	12.55	62.75	11.22	56.12	9.26	46.32	8.72	43.61
Excavation - Topsoil strip & stockpile	12.26	36.78	12.55	37.65	11.22	33.67	9.26	27.79	8.72	26.17
Base Slab - Provision & placing of concrete	3.68	404.53	3.76	414.15	3.37	370.38	2.78	305.72	2.62	287.82
Base Slab - Reinforcement (Provision & Fix)	0.41	367.76	0.42	376.50	0.37	336.71	0.31	277.93	0.29	261.65
Base Slab - Trenchfill (Grade C20)	12.26	919.39	12.55	941.25	11.22	841.77	9.26	694.82	8.72	654.13
Base Slab - Formwork	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	1.87	205.58	1.96	215.20	1.56	171.43	0.97	106.77	0.81	88.86
Wall - Reinforcement (Provision & Fix)	0.21	186.89	0.22	195.63	0.17	155.84	0.11	97.06	0.09	80.79
Wall - Formwork (textured on one side)	12.46	934.47	13.04	978.17	10.39	779.22	6.47	485.32	5.39	403.93
Wall- Granite finish	-0.80	0.00	-0.51	0.00	-1.84	0.00	-3.80	0.00	-4.34	0.00
Drainage	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management										
Additional Work										
Sub-total		3770.09		3874.71		3398.53		2695.07		2500.27
Preliminaries		565.51		581.21		509.78		404.26		375.04
TOTAL		£4,335.61		£4,455.91		£3,908.30		£3,099.33		£2,875.31

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 16 - FID 19		Wall 17 - FID 20		Wall 18 - FID 21		Wall 19 - FID 22		Wall 20 - FID 23	
Wall thickness		m	0.3		0.3		0.3		0.3		0.3	
Base thickness		m	0.3		0.3		0.3		0.3		0.3	
Wall height		m	1.04		0.97		0.94		0.93		0.97	
Base width		m	1.34		1.27		1.24		1.23		1.27	
Length of section		m	10.05		10.05		10.05		10.05		10.05	
Main Elements												
Clearance - Vegetation killing	£230.00	ha	0.00	0.31	0.00	0.29	0.00	0.29	0.00	0.28	0.00	0.29
Clearance - Site clearance & disposal	£5.00	m2	13.45	67.27	12.76	63.80	12.45	62.25	12.34	61.69	12.74	63.70
Excavation - Topsoil strip & stockpile	£3.00	m2	13.45	40.36	12.76	38.28	12.45	37.35	12.34	37.02	12.74	38.22
Base Slab - Provision & placing of concrete	£110.00	m3	4.04	443.99	3.83	421.11	3.73	410.83	3.70	407.19	3.82	420.45
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.45	403.63	0.43	382.83	0.41	373.48	0.41	370.17	0.42	382.23
Base Slab - Trenchfill (Grade C20)	£75.00	m3	13.45	1009.07	12.76	957.07	12.45	933.71	12.34	925.42	12.74	955.56
Base Slab - Formwork	£50.00	m2	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	£110.00	m3	2.23	245.04	2.02	222.16	1.93	211.88	1.89	208.24	2.01	221.50
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.25	222.76	0.22	201.96	0.21	192.62	0.21	189.30	0.22	201.36
Wall - Formwork (textured on one side)	£75.00	m2	14.85	1113.82	13.46	1009.82	12.84	963.10	12.62	946.52	13.42	1006.81
Wall- Granite finish	£80.00	m2	0.39	31.35	-0.30	0.00	-0.61	0.00	-0.72	0.00	-0.32	0.00
Drainage	£35.00	m	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management		Sum										
Additional Work												
Sub-total				4230.72		3950.46		3838.64		3798.96		3943.25
Preliminaries				634.61		592.57		575.80		569.84		591.49
TOTAL				£4,865.33		£4,543.03		£4,414.44		£4,368.80		£4,534.73

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 21 - FID 24		Wall 22 - FID 25		Wall 23 - FID 26		Wall 24 - FID 27		Wall 25 - FID 28	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	1.07		1.04		1.03		1.07		1.05	
Base width	1.37		1.34		1.33		1.37		1.35	
Length of section	10.05		10.05		10.05		10.05		10.05	
Main Elements										
Clearance - Vegetation killing	0.00	0.32	0.00	0.31	0.00	0.31	0.00	0.32	0.00	0.31
Clearance - Site clearance & disposal	13.73	68.63	13.46	67.32	13.36	66.82	13.81	69.03	13.56	67.82
Excavation - Topsoil strip & stockpile	13.73	41.18	13.46	40.39	13.36	40.09	13.81	41.42	13.56	40.69
Base Slab - Provision & placing of concrete	4.12	452.94	4.04	444.32	4.01	441.01	4.14	455.60	4.07	447.64
Base Slab - Reinforcement (Provision & Fix)	0.46	411.77	0.45	403.93	0.45	400.91	0.46	414.18	0.45	406.94
Base Slab - Trenchfill (Grade C20)	13.73	1029.42	13.46	1009.83	13.36	1002.29	13.81	1035.45	13.56	1017.36
Base Slab - Formwork	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	2.31	253.99	2.23	245.37	2.20	242.06	2.33	256.65	2.26	248.69
Wall - Reinforcement (Provision & Fix)	0.26	230.90	0.25	223.07	0.24	220.05	0.26	233.31	0.25	226.08
Wall - Formwork (textured on one side)	15.39	1154.52	14.87	1115.33	14.67	1100.25	15.55	1166.57	15.07	1130.40
Wall- Granite finish	0.66	53.05	0.40	32.16	0.30	24.11	0.74	59.48	0.50	40.19
Drainage	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management										
Additional Work										
Sub-total		4349.84		4235.15		4191.02		4385.12		4279.26
Preliminaries		652.48		635.27		628.65		657.77		641.89
TOTAL		£5,002.31		£4,870.42		£4,819.68		£5,042.89		£4,921.15

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 26 - FID 29		Wall 27 - FID 30		Wall 28 - FID 31		Wall 29 - FID 32		Wall 30 - FID 33	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	0.94		0.79		0.84		0.89		1.20	
Base width	1.24		1.09		1.14		1.19		1.50	
Length of section	10.05		10.05		10.05		10.05		10.05	
Main Elements										
Clearance - Vegetation killing	0.00	0.29	0.00	0.25	0.00	0.26	0.00	0.28	0.00	0.35
Clearance - Site clearance & disposal	12.48	62.40	10.93	54.66	11.43	57.17	12.00	59.99	15.04	75.21
Excavation - Topsoil strip & stockpile	12.48	37.44	10.93	32.80	11.43	34.30	12.00	35.99	15.04	45.13
Base Slab - Provision & placing of concrete	3.74	411.83	3.28	360.76	3.43	377.34	3.60	395.91	4.51	496.38
Base Slab - Reinforcement (Provision & Fix)	0.42	374.39	0.36	327.97	0.38	343.04	0.40	359.92	0.50	451.26
Base Slab - Trenchfill (Grade C20)	12.48	935.97	10.93	819.92	11.43	857.60	12.00	899.80	15.04	1128.14
Base Slab - Formwork	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	1.94	212.88	1.47	161.81	1.62	178.39	1.79	196.96	2.70	297.43
Wall - Reinforcement (Provision & Fix)	0.22	193.52	0.16	147.10	0.18	162.18	0.20	179.06	0.30	270.39
Wall - Formwork (textured on one side)	12.90	967.62	9.81	735.51	10.81	810.88	11.94	895.28	18.03	1351.96
Wall- Granite finish	-0.58	0.00	-2.13	0.00	-1.63	0.00	-1.07	0.00	1.98	158.36
Drainage	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management										
Additional Work										
Sub-total		3849.45		3293.91		3474.28		3676.30		4927.72
Preliminaries		577.42		494.09		521.14		551.44		739.16
TOTAL		£4,426.87		£3,787.99		£3,995.42		£4,227.74		£5,666.88

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 31 - FID 34		Wall 32 - FID 35		Wall 33 - FID 36		Wall 34 - FID 37		Wall 35 - FID 38	
Wall thickness		m	0.3		0.3		0.3		0.3		0.3	
Base thickness		m	0.3		0.3		0.3		0.3		0.3	
Wall height		m	1.16		0.86		1.15		0.82		0.59	
Base width		m	1.46		1.16		1.45		1.12		0.89	
Length of section		m	10.05		10.05		10.05		10.05		10.05	
Main Elements												
Clearance - Vegetation killing	£230.00	ha	0.00	0.34	0.00	0.27	0.00	0.33	0.00	0.26	0.00	0.21
Clearance - Site clearance & disposal	£5.00	m2	14.67	73.35	11.65	58.23	14.56	72.80	11.21	56.07	8.93	44.66
Excavation - Topsoil strip & stockpile	£3.00	m2	14.67	44.01	11.65	34.94	14.56	43.68	11.21	33.64	8.93	26.80
Base Slab - Provision & placing of concrete	£110.00	m3	4.40	484.11	3.49	384.31	4.37	480.47	3.36	370.05	2.68	294.78
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.49	440.10	0.39	349.37	0.49	436.79	0.37	336.41	0.30	267.98
Base Slab - Trenchfill (Grade C20)	£75.00	m3	14.67	1100.26	11.65	873.42	14.56	1091.97	11.21	841.02	8.93	669.95
Base Slab - Formwork	£50.00	m2	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	£110.00	m3	2.59	285.16	1.69	185.36	2.56	281.52	1.56	171.10	0.87	95.83
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.29	259.24	0.19	168.51	0.28	255.92	0.17	155.54	0.10	87.12
Wall - Formwork (textured on one side)	£75.00	m2	17.28	1296.19	11.23	842.53	17.06	1279.62	10.37	777.71	5.81	435.58
Wall- Granite finish	£80.00	m2	1.61	128.62	-1.42	0.00	1.50	119.77	-1.85	0.00	-4.13	0.00
Drainage	£35.00	m	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management		Sum										
Additional Work												
Sub-total				4764.50		3550.04		4715.98		3394.91		2576.02
Preliminaries				714.68		532.51		707.40		509.24		386.40
TOTAL				£5,479.18		£4,082.54		£5,423.38		£3,904.15		£2,962.42

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 36 - FID 39		Wall 37 - FID 40		Wall 38 - FID 41		Wall 39 - FID 42		Wall 40 - FID 43	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	1.22		1.37		1.32		1.15		1.09	
Base width	1.52		1.67		1.62		1.45		1.39	
Length of section	10.05		10.05		10.05		10.05		10.05	
Main Elements										
Clearance - Vegetation killing	0.00	0.35	0.00	0.38	0.00	0.37	0.00	0.33	0.00	0.32
Clearance - Site clearance & disposal	15.29	76.47	16.73	83.65	16.25	81.24	14.54	72.70	13.98	69.88
Excavation - Topsoil strip & stockpile	15.29	45.88	16.73	50.19	16.25	48.74	14.54	43.62	13.98	41.93
Base Slab - Provision & placing of concrete	4.59	504.67	5.02	552.09	4.87	536.17	4.36	479.80	4.19	461.23
Base Slab - Reinforcement (Provision & Fix)	0.51	458.79	0.56	501.90	0.54	487.43	0.48	436.18	0.47	419.30
Base Slab - Trenchfill (Grade C20)	15.29	1146.98	16.73	1254.74	16.25	1218.56	14.54	1090.46	13.98	1048.26
Base Slab - Formwork	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44	6.03	301.44
Wall - Provision & placing of concrete	2.78	305.72	3.21	353.14	3.07	337.22	2.55	280.85	2.38	262.28
Wall - Reinforcement (Provision & Fix)	0.31	277.93	0.36	321.03	0.34	306.56	0.28	255.32	0.26	238.44
Wall - Formwork (textured on one side)	18.53	1389.64	21.40	1605.17	20.44	1532.81	17.02	1276.60	15.90	1192.20
Wall- Granite finish	2.23	178.45	3.67	293.40	3.19	254.81	1.48	118.17	0.91	73.15
Drainage	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68	10.05	351.68
Traffic Management										
Additional Work										
Sub-total		5037.99		5668.81		5457.03		4707.15		4460.12
Preliminaries		755.70		850.32		818.55		706.07		669.02
TOTAL		£5,793.69		£6,519.14		£6,275.58		£5,413.23		£5,129.14

	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall	Wall 41 - FID 44		Wall 42 - FID 45		Wall 43 - FID 1		Wall 44 - FID 46		Wall 45 - FID 47	
Wall thickness	0.3		0.3		0.3		0.3		0.3	
Base thickness	0.3		0.3		0.3		0.3		0.3	
Wall height	1.01		0.48		0.62		0.72		1.36	
Base width	1.31		0.78		0.92		1.02		1.66	
Length of section	10.05		10.05		9.92		9.92		9.92	
Main Elements										
Clearance - Vegetation killing	0.00	0.30	0.00	0.18	0.00	0.21	0.00	0.23	0.00	0.38
Clearance - Site clearance & disposal	13.19	65.97	7.87	39.34	9.10	45.51	10.15	50.77	16.48	82.40
Excavation - Topsoil strip & stockpile	13.19	39.58	7.87	23.60	9.10	27.31	10.15	30.46	16.48	49.44
Base Slab - Provision & placing of concrete	3.96	435.37	2.36	259.63	2.73	300.40	3.05	335.08	4.94	543.85
Base Slab - Reinforcement (Provision & Fix)	0.44	395.79	0.26	236.03	0.30	273.09	0.34	304.62	0.55	494.41
Base Slab - Trenchfill (Grade C20)	13.19	989.48	7.87	590.07	9.10	682.72	10.15	761.55	16.48	1236.03
Base Slab - Formwork	6.03	301.44	6.03	301.44	5.95	297.48	5.95	297.48	5.95	297.48
Wall - Provision & placing of concrete	2.15	236.42	0.55	60.68	0.95	104.06	1.26	138.74	3.16	347.52
Wall - Reinforcement (Provision & Fix)	0.24	214.93	0.06	55.16	0.11	94.60	0.14	126.13	0.35	315.92
Wall - Formwork (textured on one side)	14.33	1074.63	3.68	275.82	6.31	472.99	8.41	630.66	21.06	1579.62
Wall- Granite finish	0.13	10.45	-5.19	0.00	-3.79	0.00	-2.74	0.00	3.59	287.17
Drainage	10.05	351.68	10.05	351.68	9.92	347.06	9.92	347.06	9.92	347.06
Traffic Management										
Additional Work										
Sub-total		4116.03		2193.63		2645.42		3022.79		5581.28
Preliminaries		617.41		329.04		396.81		453.42		837.19
TOTAL		£4,733.44		£2,522.67		£3,042.23		£3,476.20		£6,418.47

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 46 - FID 48		Wall 47 - FID 49		Wall 48 - FID 50		Wall 49 - FID 51		Wall 50 - FID 52		Wall 51 - FID 53	
Wall thickness		m	0.3		0.3		0.3		0.3		0.3		0.3	
Base thickness		m	0.3		0.3		0.3		0.3		0.3		0.3	
Wall height		m	1.28		1.21		1.03		0.95		0.81		0.74	
Base width		m	1.58		1.51		1.33		1.25		1.11		1.04	
Length of section		m	9.92		9.916		9.916		9.916		9.916		9.916	
Main Elements														
Clearance - Vegetation killing	£230.00	ha	0.00	0.36	0.00	0.35	0.00	0.30	0.00	0.29	0.00	0.25	0.00	0.24
Clearance - Site clearance & disposal	£5.00	m2	15.70	78.49	15.01	75.06	13.20	65.99	12.40	62.02	11.03	55.13	10.33	51.66
Excavation - Topsoil strip & stockpile	£3.00	m2	15.70	47.09	15.01	45.04	13.20	39.59	12.40	37.21	11.03	33.08	10.33	31.00
Base Slab - Provision & placing of concrete	£110.00	m3	4.71	518.00	4.50	495.42	3.96	435.54	3.72	409.36	3.31	363.88	3.10	340.97
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.52	470.91	0.50	450.38	0.44	395.95	0.41	372.15	0.37	330.80	0.34	309.97
Base Slab - Trenchfill (Grade C20)	£75.00	m3	15.70	1177.28	15.01	1125.96	13.20	989.87	12.40	930.37	11.03	827.00	10.33	774.94
Base Slab - Formwork	£50.00	m2	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48
Wall - Provision & placing of concrete	£110.00	m3	2.92	321.67	2.72	299.09	2.17	239.20	1.94	213.03	1.52	167.54	1.31	144.64
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.32	292.42	0.30	271.90	0.24	217.46	0.22	193.66	0.17	152.31	0.15	131.49
Wall - Formwork (textured on one side)	£75.00	m2	19.49	1462.11	18.13	1359.48	14.50	1087.29	12.91	968.30	10.15	761.55	8.77	657.43
Wall- Granite finish	£80.00	m2	2.81	224.50	2.12	169.76	0.31	24.59	-0.49	0.00	-1.86	0.00	-2.56	0.00
Drainage	£35.00	m	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06
Traffic Management		Sum												
Additional Work														
Sub-total				5237.37		4936.98		4140.33		3830.93		3336.08		3086.87
Preliminaries				785.61		740.55		621.05		574.64		500.41		463.03
TOTAL				£6,022.97		£5,677.53		£4,761.38		£4,405.56		£3,836.49		£3,549.90

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 52 - FID 54		Wall 53 - FID 55		Wall 54 - FID 56		Wall 55 - FID 57		Wall 56 - FID 58		Wall 57 - FID 59	
Wall thickness		m	0.3		0.3		0.3		0.3		0.3		0.3	
Base thickness		m	0.3		0.3		0.3		0.3		0.3		0.3	
Wall height		m	0.56		0.49		0.35		0.29		0.17		0.05	
Base width		m	0.86		0.79		0.65		0.59		0.47		0.35	
Length of section		m	9.916		9.916		9.916		9.916		9.916		9.916	
Main Elements														
Clearance - Vegetation killing	£230.00	ha	0.00	0.20	0.00	0.18	0.00	0.15	0.00	0.14	0.00	0.11	0.00	0.08
Clearance - Site clearance & disposal	£5.00	m2	8.55	42.74	7.85	39.27	6.47	32.33	5.87	29.35	4.68	23.40	3.49	17.45
Excavation - Topsoil strip & stockpile	£3.00	m2	8.55	25.64	7.85	23.56	6.47	19.40	5.87	17.61	4.68	14.04	3.49	10.47
Base Slab - Provision & placing of concrete	£110.00	m3	2.56	282.07	2.36	259.16	1.94	213.35	1.76	193.72	1.40	154.45	1.05	115.18
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.28	256.43	0.26	235.60	0.22	193.96	0.20	176.11	0.16	140.41	0.12	104.71
Base Slab - Trenchfill (Grade C20)	£75.00	m3	8.55	641.07	7.85	589.01	6.47	484.89	5.87	440.27	4.68	351.03	3.49	261.78
Base Slab - Formwork	£50.00	m2	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48	5.95	297.48
Wall - Provision & placing of concrete	£110.00	m3	0.78	85.73	0.57	62.83	0.15	17.02	-0.02	-2.62	-0.38	-41.88	-0.74	-81.15
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.09	77.94	0.06	57.12	0.02	15.47	0.00	-2.38	-0.04	-38.08	-0.08	-73.78
Wall - Formwork (textured on one side)	£75.00	m2	5.20	389.70	3.81	285.58	1.03	77.35	-0.16	-11.90	-2.54	-190.38	-4.92	-368.88
Wall- Granite finish	£80.00	m2	-4.34	0.00	-5.04	0.00	-6.43	0.00	-7.02	0.00	-8.21	0.00	-9.40	0.00
Drainage	£35.00	m	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06	9.92	347.06
Traffic Management		Sum												
Additional Work														
Sub-total				2446.06		2196.86		1698.45		1484.84		1057.64		630.42
Preliminaries				366.91		329.53		254.77		222.73		158.65		94.56
TOTAL				£2,812.97		£2,526.38		£1,953.22		£1,707.56		£1,216.28		£724.98

Total Cost of Walls for FC1 £235,080.09

Flood Cell 2: Seal Manholes	
Number of Manholes	Cost
2.82m depth to invert	£12,780.50
1.82m depth to invert	£6,755.40
1.681m depth to invert	£6,755.40
1.449m depth to invert	6755.4
Sub-total	£33,046.70
Preliminaries	£4,957.01
Total	£38,003.71

Flood Cell 3: Hard Defences - Walls

	Rate	Units	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Reinforced concrete retaining wall			Wall 1 - FID 4		Wall 2 - FID 75		Wall 3 - FID 76		Wall 4 - FID 77	
Wall thickness		m	0.30		0.30		0.30		0.3	
Base thickness		m	0.30		0.30		0.30		0.3	
Wall height		m	0.39		0.71		0.80		0.65	
Base width		m	0.69		1.01		1.10		0.95	
Length of section		m	9.95		9.95		9.95		9.95	
Main Elements										
Clearance - Vegetation killing	£230.00	ha	0.001	£0.16	0.001	£0.23	0.001	£0.25	0.00	£0.22
Clearance - Site clearance & disposal	£5.00	m2	6.915	£34.57	9.999	£49.99	10.924	£54.62	9.43	£47.16
Excavation - Topsoil strip & stockpile	£3.00	m2	6.915	£20.74	9.999	£30.00	10.924	£32.77	9.43	£28.29
Base Slab - Provision & placing of concrete	£110.00	m3	2.074	£228.18	3.000	£329.96	3.277	£360.49	2.83	£311.24
Base Slab - Reinforcement (Provision & Fix)	£900.00	t	0.230	£207.44	0.333	£299.96	0.364	£327.72	0.31	£282.95
Base Slab - Trenchfill (Grade C20)	£75.00	m3	6.915	£518.59	9.999	£749.91	10.924	£819.30	9.43	£707.37
Base Slab - Formwork	£50.00	m2	5.969	£298.47	5.969	£298.47	5.969	£298.47	5.97	£298.47
Wall - Provision & placing of concrete	£110.00	m3	0.284	£31.19	1.209	£132.97	1.486	£163.50	1.04	£114.25
Wall - Reinforcement (Provision & Fix)	£900.00	t	0.032	£28.35	0.134	£120.88	0.165	£148.64	0.12	£103.87
Wall - Formwork (textured on one side)	£75.00	m2	1.890	£141.77	8.059	£604.40	9.909	£743.19	6.92	£519.34
Wall- Granite finish	£80.00	m2	-6.019	£0.00	-2.935	£0.00	0.000	£0.00	0.00	£0.00
Drainage	£35.00	m	9.949	£348.22	9.949	£348.22	9.949	£348.22	9.95	£348.22
Traffic Management		Sum								
Additional Work										
Sub-total				£1,857.68		£2,964.99		£3,297.17		£2,761.38
Preliminaries				£278.65		£444.75		£494.58		£414.21
TOTAL				£2,136.34		£3,409.73		£3,791.75		£3,175.59

Total Cost of Walls for FC3 £12,513.41

Flood Cell 4: Seal Manholes	
Number of Manholes	Cost
10	£67,554.00
2	£25,561.00
Sub-total	£93,115.00
Preliminaries	£13,967.25
Total	£107,082.25

Flood Cell 5: Seal Manholes	
Number of Manholes	Cost
10	£67,554.00
8	£102,244.00
Sub-total	£169,798.00
Preliminaries	£25,469.70
Total	£195,267.70

Summary	
Flood Cell 1 Hard Defences - Walls	£235,080.09
Flood Cell 2 - Sealing Manholes	£38,003.71
Flood Cell 3 Hard Defences - Walls	£12,513.41
Flood Cell 4 - Sealing Manholes	£107,082.25
Flood Cell 5 - Sealing Manholes	£195,267.70
Sub-Total	£587,947.16
Fees & Contingencies (10%)	£58,794.72
Total Option 3 Cost	£646,741.87