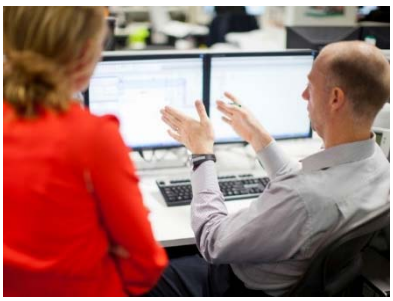
# River Bride (Blackpool) Drainage Scheme

## Flood Risk Management Options Assessment Report

Issue 1 | January 2016

OPW ARUP JBA consulting

Office of Public Works

# River Bride (Blackpool) Certified Drainage Scheme

## Flood Risk Management Options Report

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**Ove Arup & Partners Ireland Ltd**
15 Oliver Plunkett Street
Cork
Ireland
www.arup.com

**JBA Consulting Engineers and Scientists Limited**
24 Grove Island
Corbally
Limerick
Ireland
www.jbaconsulting.ie

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# 1 Introduction

## 1.1 Context

Arup in association with JBA Consulting were commissioned by the Office of Public Works (OPW) to develop the River Bride (Blackpool) Certified Drainage Scheme. The scheme will be designed to provide protection to properties in the study area from the 1 in 100 year fluvial / 1 in 200 year tidal flood events.

There are five stages to the project:

- Stage I - Development of a number of flood defence options and the identification of a preferred Scheme
- Stage II - Public exhibition
- Stage III - Detailed design, confirmation and tender
- Stage IV –Construction
- Stage V - Handover of works

This Options Assessment Report is produced as part of Stage 1 of the project, and covers the Commons Road / Blackpool Village area.

## 1.2 Scope of Report

The purpose of this report is to assess all of the possible flood relief options that could be implemented in the Commons Road / Blackpool Village area and to outline the procedure for how the preferred option was developed and selected. The process for the selection of the preferred flood relief options is outlined below:

1. An initial screening of a long list of possible flood risk management measures against a predetermined set of criteria, was carried out in order to determine their potential viability.
2. A technical assessment of the potentially viable flood risk management measures was undertaken.
3. Potential flood relief options were developed using combinations of those flood risk management measures which were determined to be technically viable.
4. These flood relief options were then subjected to economic, environmental, and multi-criteria assessments, allowing a preferred flood relief option to be selected.

## 1.3 Study Area

The area for which flood relief measures are to be identified is located to the north of Cork City centre, and consists of the urbanised area from Blackpool village centre to the railway viaduct just upstream of North Point Business Park.

The study area is located in the Bride (North) catchment as shown in **Figure 1** below. The source of the Bride (North) River is close to Healy's Bridge in the west of the catchment area. The river flows in an easterly direction adjacent to the Lower Killeens Road before it is joined by the Glenamought Stream downstream of Blackstone Bridge. The Glenamought is the larger of the two catchments to this point. The Bride River then flows in a southeasterly direction, parallel to the Commons Road, before it crosses the roadway adjacent to the North Point Business Park. The river then travels south to Orchard Court in Blackpool Village. The Bride is joined by the Glen River downstream of Blackpool in an area known as Madden's Buildings, after which it is known as the Kiln River. The Bride/Kiln is predominantly culverted between Blackpool Church and its confluence with the Lee at Christy Ring Bridge.

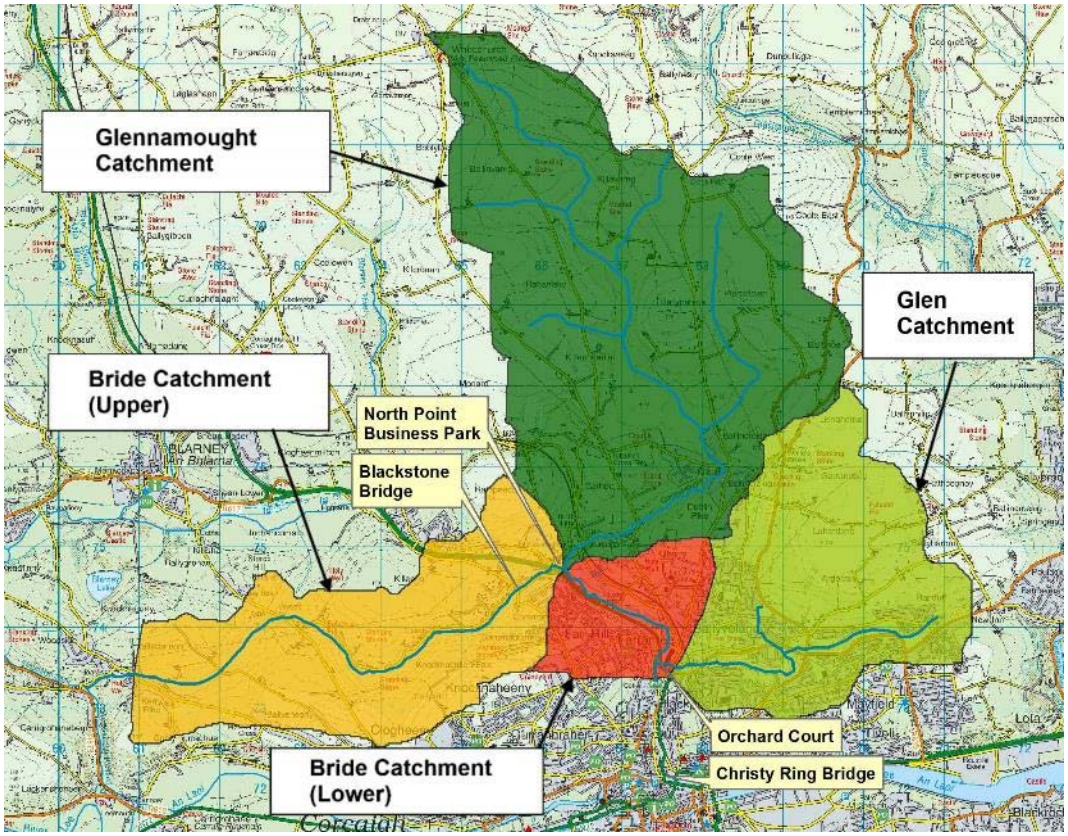


Figure 1 Bride (North) River Catchment

A chainage system for the river system has been developed for this project and is used throughout this report, for reference purposes. The channel code comprises a three character prefix which is unique to each channel followed by a channel chainage (in metres). The prefix of the channel codes are listed and illustrated in **Figure 2**. The chainage of each channel commences at Ch.0m at the downstream end of each watercourse. For example C04_35 refers to Ch.35m on the Glen River.

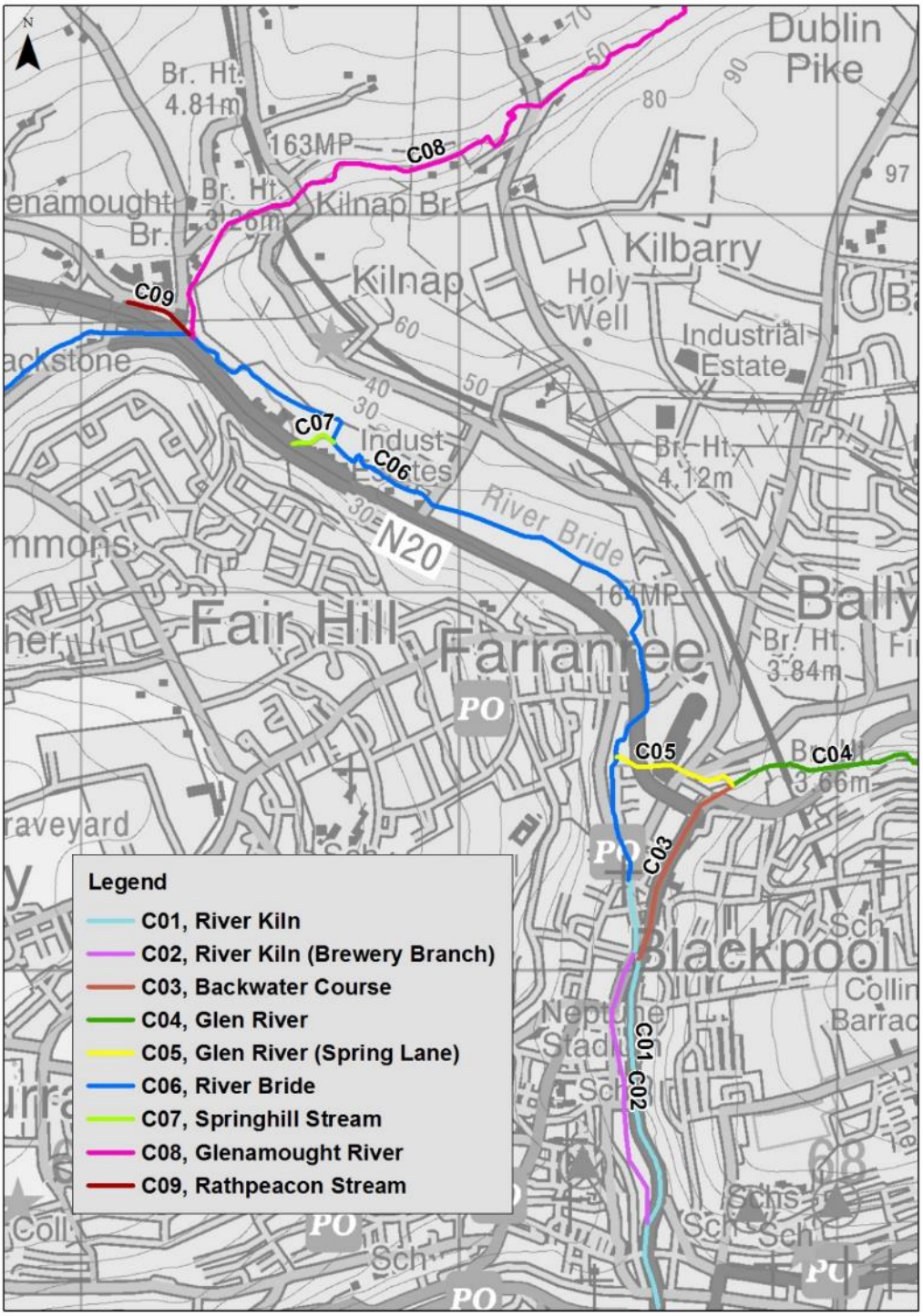


Figure 2 Blackpool Channel Codes

## 1.4 Scope of Problem

A hydrological study and hydraulic modelling of the existing situation has been carried out as part of this project and is reported on separately[1]. The existing flood risk and flood mechanisms are described in detail in the hydrology report and hydraulics report. The predicted 1 in 100 year flood extent is shown in **Figure 3** and **Figure 4.**

This report concentrates on key areas where flood risk is greatest, in particular along the Commons Road and through Blackpool Village as shown in **Figure 3** and **Figure 4** below.

[1] Refer to River Bride (Blackpool) Certified Drainage Scheme – Hydrological and Hydraulic Modelling Report available for download from the project website – www.lowerleefrs.ie.

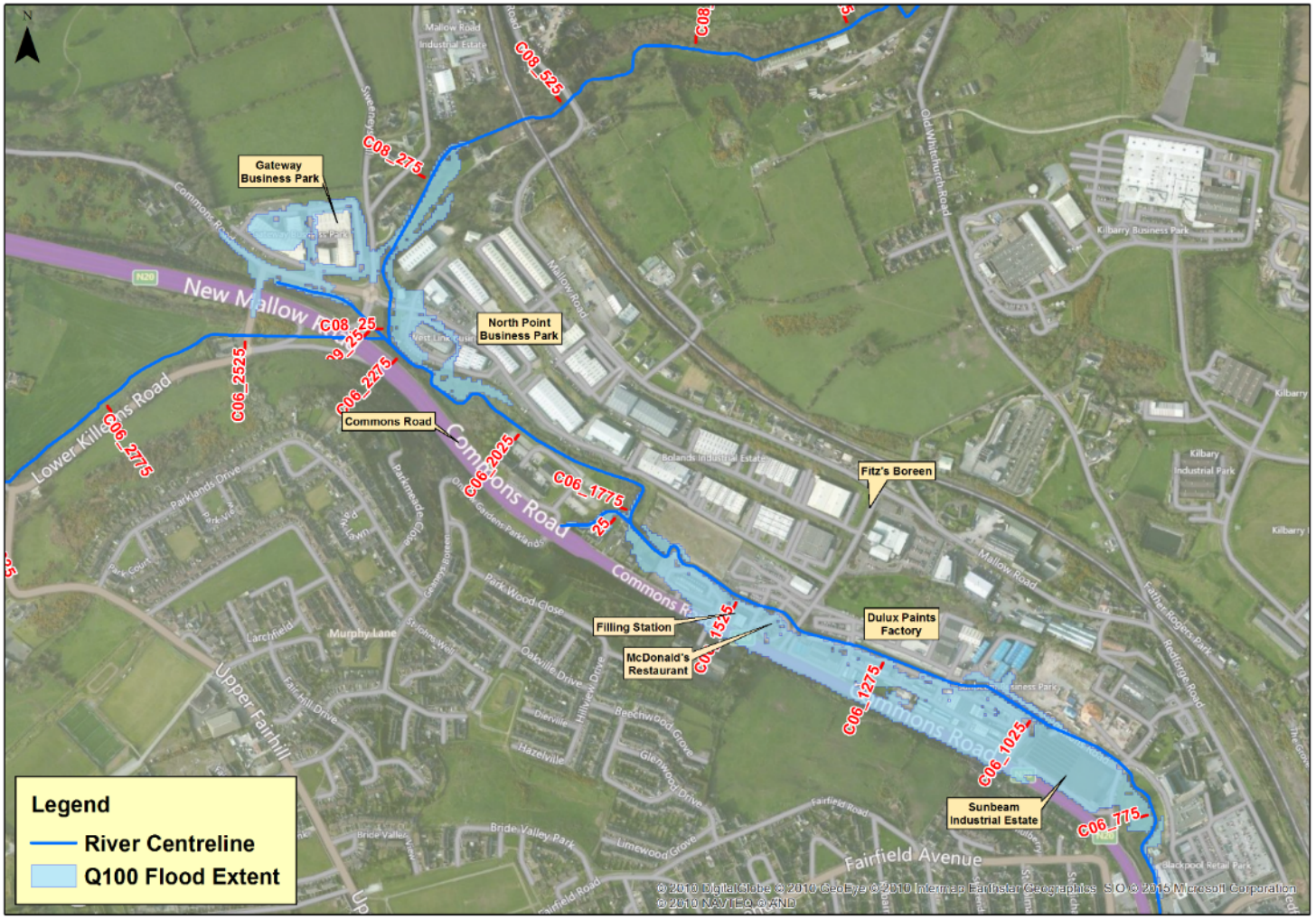


Figure 3 Critical Areas at Risk, Commons Road

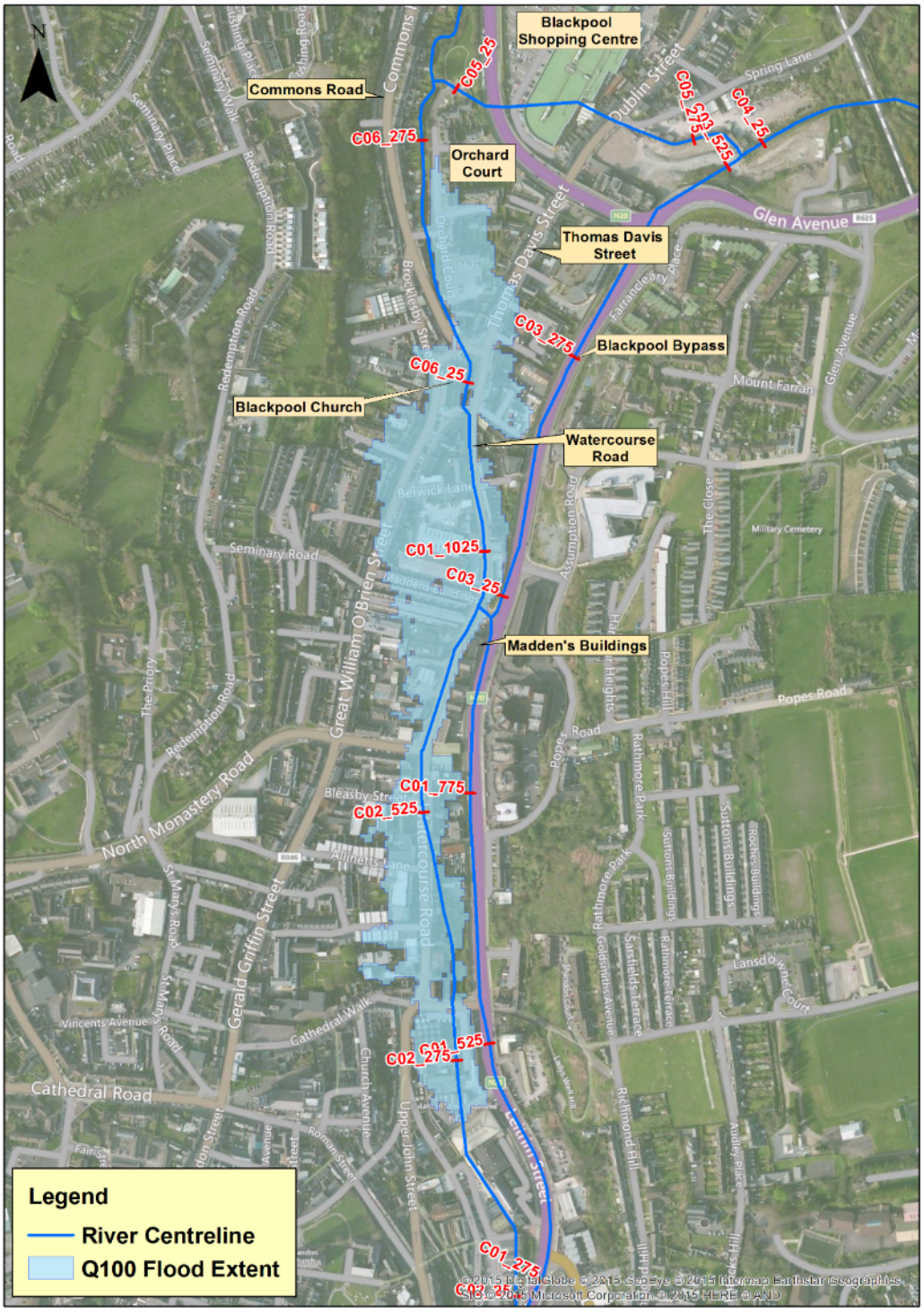


Figure 4 Critical Area at Risk, Blackpool Village

# 2 Stakeholder Input and Constraints

## 2.1 Constraints Study

A Constraints Study Report was prepared as part of this project. It was a joint Constraints Report for the Lower Lee (Cork City) Drainage Scheme and the River Bride (Blackpool) Certified Drainage Scheme as it preceded the separate of both elements into discreet schemes.

Constraints were assessed under the following headings:

- Human Beings
- Ecology
- Water
- Soils and Geology
- Archaeology, Architectural and Cultural Heritage
- Landscape
- Noise, Air Quality and Climate
- Material Assets

The constraints identified in the report have been taken into account in the development of the preferred option.

## 2.2 Public Consultation Days

Two separate Public Information Days (PIDs) were held during the course of Phase I of the study.

The first PID was held in Cork City Hall on 17 July 2013. The purpose of the PID was to present the Study Area to the general public and to outline the process involved in the preparation of the Lower Lee Flood Relief Scheme[2]. A summary of the submissions received from the public is included in the project's Constraints Study Report[3].

The second PID was held in Cork City Hall on 29 July 2014. The purpose of this PID was to present the emerging preferred option for the scheme and invite comments.

The feedback received from both PIDs was taken on board and helped to inform the development of the preferred option. Further details of the feedback received are discussed later in this report.

[2] Comprising both the Lower Lee (Cork City) Drainage Scheme and the River Bride (Blackpool) Certified Drainage Scheme.
[3] Refer to Lower Lee (Cork City) Flood Relief Scheme (including Blackpool and Ballyvolane) Constraints Study Report available for download from the project website – www.lowerleefrs.ie.

## 2.3 Consultation with Blackpool Flood Committee

Regular meetings were held between the Design Team, Cork City Council and Blackpool Flood Committee during the preliminary design of the options. The meetings facilitated an open dialogue on the developing options, and allowed useful local knowledge to inform the scheme development.

# 3 Initial Screening of Potentially Viable Measures

## 3.1 Introduction

This section details all of the flood risk management measures considered during the initial screening stage. These measures were assessed with regard to their viability in terms of the following criteria:

- Applicability to the area;
- Economic (potential benefits, impacts, likely costs etc.);
- Environmental (potential impacts and benefits);
- Social (impacts on people, society and the likely acceptability of the measure); and
- Cultural (potential benefits and impacts upon heritage sites and resources).

The flood risk management measures which have been reviewed, as part of this initial screening process are contained in **Table 1** below.

Table 1 Initial Screening of Measures

| Possible Flood Risk Management Measure | Applicability | Economic | Environmental | Social | Cultural | Initial Screening Result | Comment |
|---|---|---|---|---|---|---|---|
| Do Nothing | Y | N | Y | N | Y | Not Viable | High risk to Economy & Society. |
| Do Minimum | Y | Y | Y | Y | Y | Potentially viable | Further Technical Assessment Required. Utilised as baseline for assessment of the benefits of the proposed scheme. |
| **Non-structural Measures** | | | | | | | |
| Planning Control | N | | | | | Not Viable | Long time to implement, and would not reduce the flood risk to an acceptable level. However, the requirement for future planning control to facilitate any potential future upstream storage to allow adaptation for climate change is important and is discussed further in this report. Compliance with Planning System and Flood Risk Management guidelines will be important to ensure that flood risk is not increased as a result of future development in the catchment. |
| Building Regs. | N | | | | | Not Viable | |
| Flood Forecasting | N | | | | | Not Viable | Possibility to extend the Lower Lee flood forecasting system in the future to include the Bride North Catchment. Not carried forward at this stage at the Bride Catchment is quite flashy and potential benefit is limited where the likely scheme will be relatively passive in nature (i.e. no demountable defences requiring intervention) |
| Public Awareness | N | | | | | Not Viable | Long time to implement, and would not reduce the flood risk to an acceptable level. |
| Land Use Management | N | | | | | Not Viable | Long time to implement, and would not reduce the flood risk to an acceptable level. However, refer to note above in relation to Planning Control and potential future upstream storage. |
| **Structural Measures** | | | | | | | |
| Upstream Storage | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Direct Flood Defences | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Diversion Channels or Culverts | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Conveyance Improvements | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Relocation | N | | | | | Not Viable | Too large a number of properties located in the Blackpool area. |
| Individual Property Protection | N | | | | | Not Viable | Too large a number of properties located in the Blackpool area. |
| Pumping | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Sediment Management | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |
| Debris Control | Y | Y | Y | Y | Y | Potentially Viable | Undertake Technical Assessment. |

## 3.2 Non-Viable Flood Risk Management Measures

Further to the initial screening, the following flood risk management measures have been identified as being non-viable and have not been carried forward for further technical assessment:

- Do Nothing
- Property Relocation
- Individual Property Protection
- Non-structural Measures
  - Planning Control
  - Building Regulations
  - Flood Forecasting
  - Public Awareness
  - Land Use Management

The '**Do Nothing'** scenario is defined as the option involving no future expenditure on flood defences or maintenance of existing defences/channels etc. The implication is that the existing risk of flooding persists in the study area. This is not considered to be a sustainable option as it fails to meet the needs of the residents and business owners in Blackpool and has therefore been ruled out at the initial screening stage.

**Relocation** involves moving the occupiers of properties at risk to new properties constructed outside of the area at risk. Due to the large number of properties at risk in Blackpool area, property relocation has been ruled out of at the initial screening stage.

**Individual property protection** protects properties on an individual basis, and typically involves measures such as demountable barriers on doors and non-return valves on drains. These measures are typically only effective up to approximately 0.6m flood depth. Above this depth, the water pressure on the walls of typical domestic properties may cause structural damage.

Individual property protection measures are not considered feasible for the Blackpool area due to the large number of properties at risk and the large predicted flood depths (>0.6m in many places). Therefore this option was ruled out at the initial screening stage.

**Non-structural measures** such as land use management within a catchment affect the way in which rainfall is directed to watercourses. Hard surfaces reduce the amount of rainfall that can infiltrate to ground water, and intensive drainage schemes will increase the speed of runoff, giving rise to earlier and higher flood peaks. River restoration is about mitigating the negative impacts that past changes in catchment management practices, such as land drainage or deforestation, may have had on river systems. Modifications to land drainage systems within the catchment can reduce the rate at which rainfall is conveyed into the river channel and thus help to reduce peak flows. This option would take a long time to implement and would not reduce the flood risk to an acceptable level and

therefore has not been carried forward for further technical assessment. The proposed scheme would not however, prevent such methods being implemented in the future.

**Flood forecasting and warning** plays a role in flood defence, firstly as a means of avoiding loss of life, and secondly to provide a warning which allows property owners and authorities to take measures to mitigate against the effects of the flood event. The Lower Lee Flood Relief Scheme is currently at preliminary design stage and a flood forecasting system is being developed for the entire Lower Lee catchment. It is possible that the Lower Lee flood forecasting system could be extended in the future to include the Bride North Catchment. Therefore the option of an independent flood forecasting system was not taken forward for detailed assessment.

## 3.3 Potentially Viable Flood Risk Management Measures

Further to the initial screening, the following flood risk management measures were identified as potentially viable measures for the Commons Road/Blackpool Village areas and have been taken forward for further technical assessment in Section 4 below:

- Do Minimum
- Structural Measures
  - Upstream Storage
  - Direct Flood Defences
  - Culverting Open Watercourses
  - Diversion Channels (or Culverts)
  - Conveyance Improvements
  - Debris Control
  - Sediment Management
  - Pumping
  - Combination of the above

# 4 Further Assessment of Potentially Viable Measures

## 4.1 Do Minimum

The “do-minimum” measure consists predominantly of ongoing maintenance works. This is in order to maintain the existing standard of protection and minimise the risks of blockage of the culvert system. Maintaining existing culverts free of debris, clearing channels of vegetation and keeping gullies clear are typical of the do-minimum approach.

The “do-minimum” measure has been taken forward for further development and costing, primarily for the purpose of using it as the baseline scenario for the scheme. This will allow a proper comparison between the existing situation and the benefits of the other viable options.

## 4.2 Upstream Storage

This approach seeks to store flood waters upstream of Blackpool in a designated storage area such that the flow entering the area at risk would be regulated to ensure that the capacity of the existing channel/culvert downstream is not exceeded.

The design peak flows (i.e. 1 in 100 year flows) at various points along the water courses are illustrated in **Figure 5** below for the existing situation.

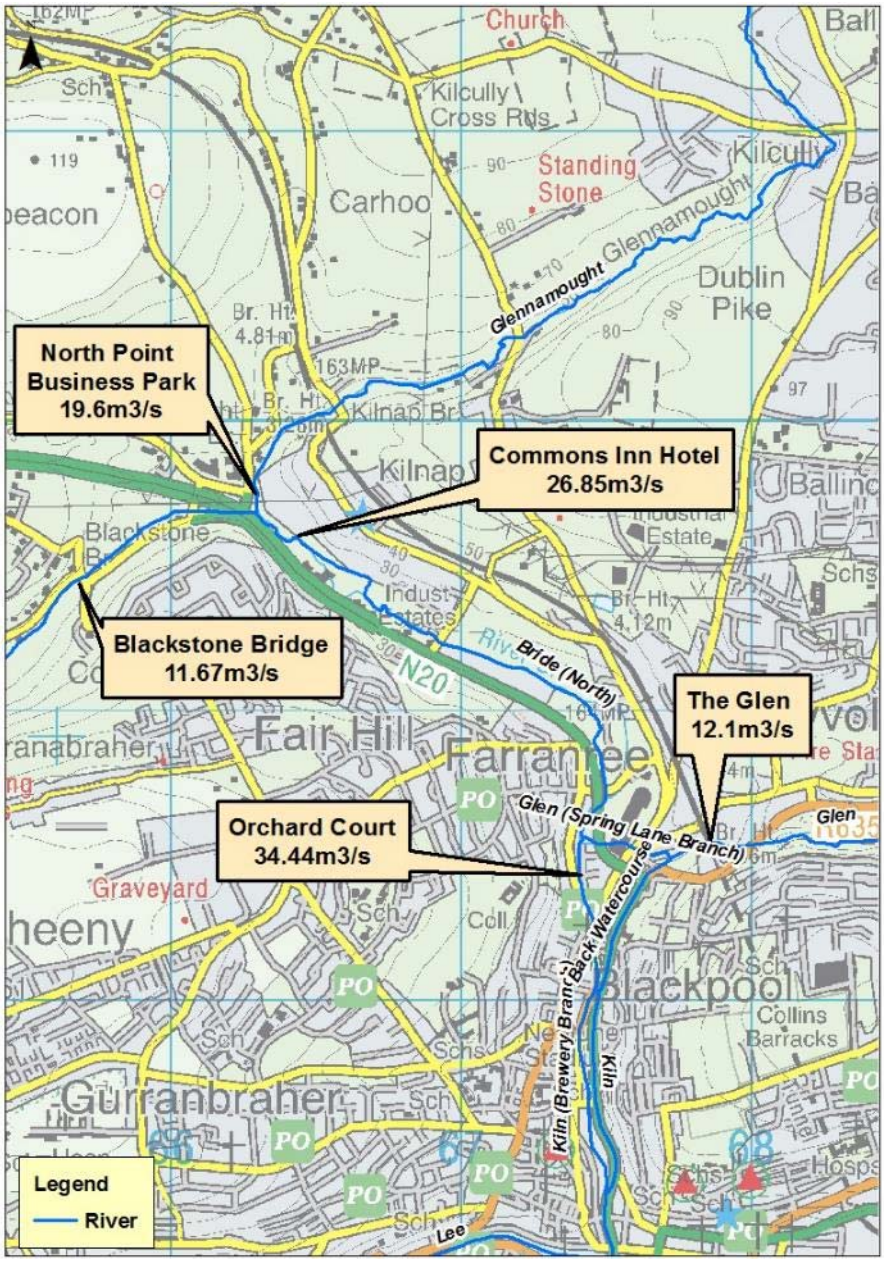


Figure 5 Existing Peak Flows for the Design Event (1 in 100 year).

In order for the upstream storage measure to be considered technically viable, it must have the capacity to reduce the peak flow through the Blackpool culverts to approximately the capacities of the existing culvert. The existing culvert capacity through Blackpool Village is approximately 22m$^3$/s while the 1 in 100 year flow at Blackpool Village is estimated to be 34.44m$^3$/s. A storage area with capacity to

reduce the peak of the 1 in 100 year event in Blackpool village by approximately 10m$^3$/s to 12m$^3$/s would therefore be needed to be considered technically viable.

The reduced peak flow of circa 22 - 24m$^3$/s could be passed through the existing culvert system without surcharging of the culvert system and localised defenses and/or other appropriate measures could be implemented along the open channel sections along Commons Road and through Blackpool Village.

The catchment was reviewed for potential storage areas using LiDAR digital terrain mapping and OS maps, considering land use and topography. No suitable storage areas of sufficient size were identified on the Bride (North) between its confluence with the Glenamought River *(C06_2306)* and Orchard Court *(C06_0440)*. This is due to the heavy urbanisation of the river valley in this area.

Upstream of the Bride/Glenamought confluence, river reaches with greater potential for storage areas were identified as follows:

- Bride North, upstream of its confluence with the Glenamought River;
- The Glenamought River; and
- A combination of both the above reaches.

### 4.2.1 Storage on the Bride North River

The 1 in 100 year flow on the Bride North, upstream of the confluence with the Glenamought, is 11.67m$^3$/s. This suggests that in order for storage on this river reach to be deemed technically viable, the peak flow would have to be reduced by approximately 85%. Significant storage capacity would be required in order to achieve this reduction in flow. Two potential locations (**Figure 6**) on the Bride River were assessed in this regard:

A. Killard

B. Upstream of Blackstone Bridge

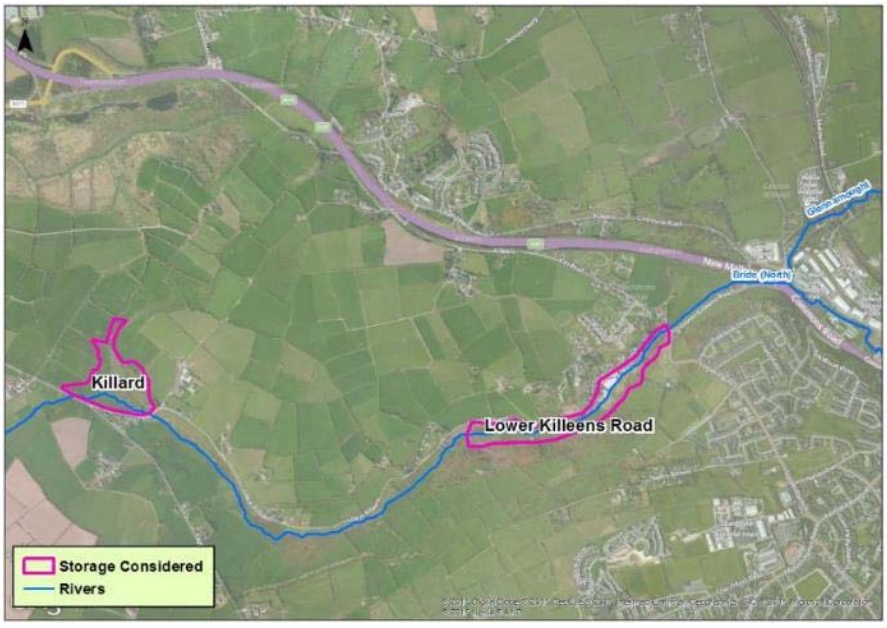


Figure 6 Upstream Storage Areas Considered (Bride North)

## A. Bride North River, Killard

This potential storage area (**Figure 7**) is located on a region of pastoral land in the townland of Killard, approximately 3.5km southeast of Blarney. There is the potential for approximately **116,000m$^3$** of storage at this location. However, the capacity of the area to limit peak flows in Blackpool is low due to the fact that only 10% of the total catchment to North Point Business Park (including the Glenamought) would be captured. Furthermore, extensive flood defence walls would be required to prevent inundation of roads and properties around the storage area. Therefore this storage location is not deemed technically or economically viable.

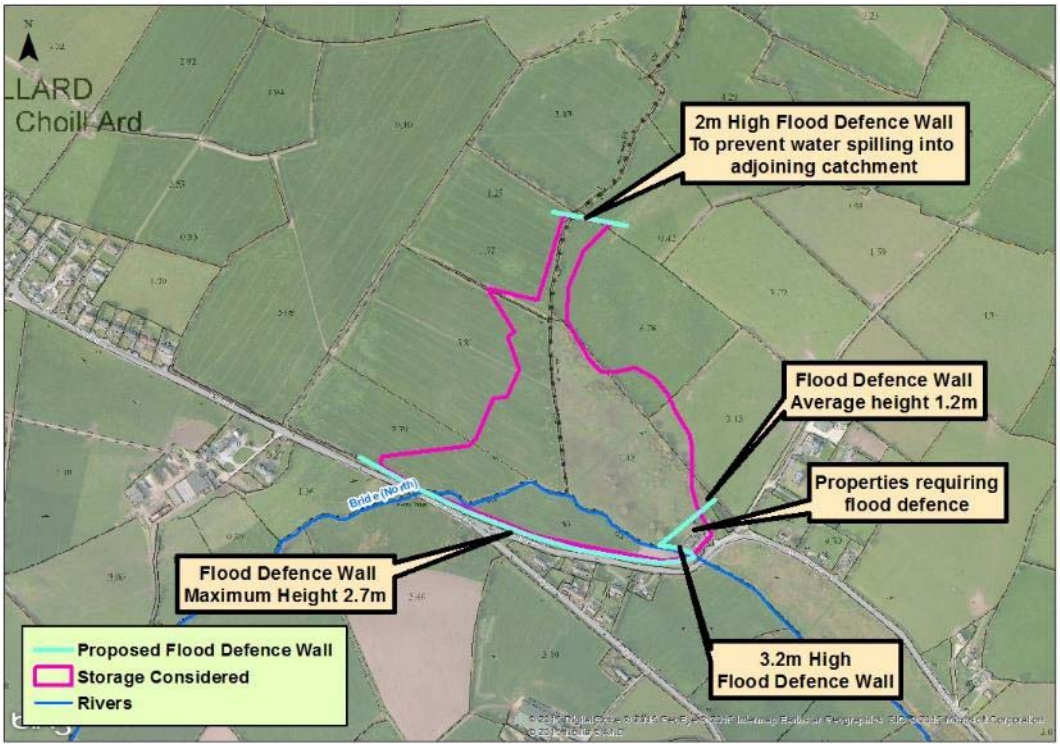


Figure 7 Possible Upstream Storage, Killard

### B. Bride North River, Upstream of Blackstone Bridge

This potential storage area (**Figure 8**) is located upstream side of Blackstone Bridge, running parallel with the Lower Killeen's Road. It is a relatively flat area of land in an otherwise steep part of the watercourse. Due to the site constraints there is only potential for approximately **87,000m$^3$** of storage. This would not sufficiently reduce the flow downstream at the areas at risk. Furthermore, given the significant defences that would be required, this location alone is not considered to be a technically viable solution.

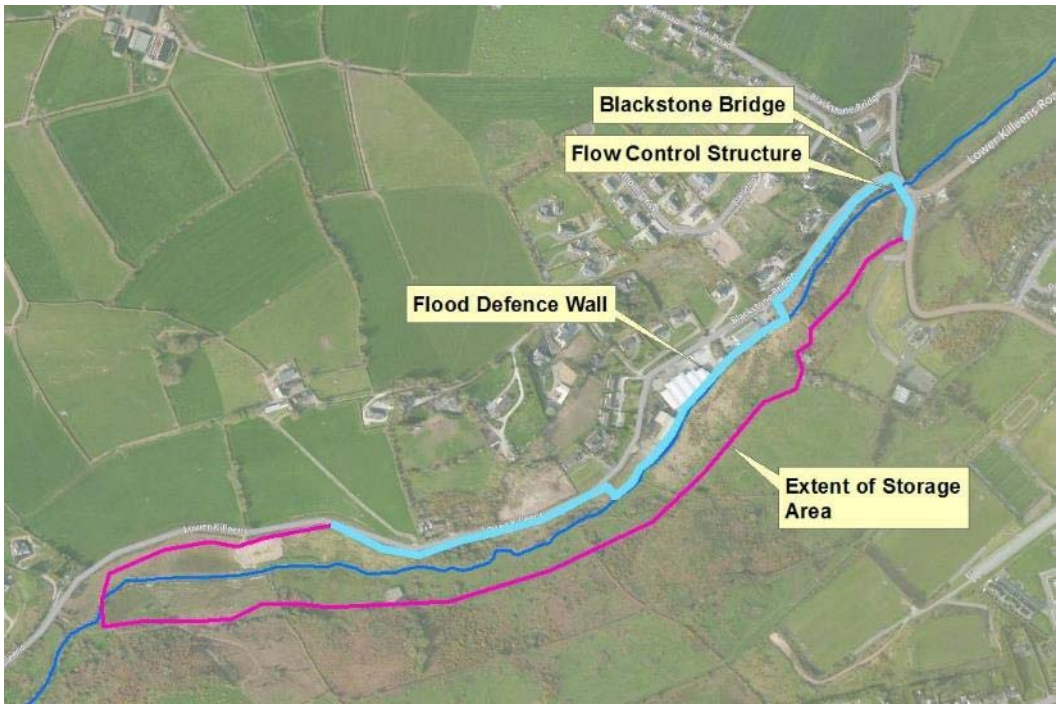


Figure 8 Possible Storage, Upstream of Blackstone Bridge

## 4.2.2 Storage on Glenamought River

In the 1 in 100 year event, flow on the Glenamought is estimated to be 19.6m$^3$/s. In order for storage on this river reach to be technically viable, the peak flow would have to be reduced by approximately 50% to 60%. Significant storage would be required in order to achieve this flow reduction.

One potentially suitable storage location was identified on the Glenamought River, which is detailed below.

### A. Glenamought River, Ballincrokig

The potentially suitable storage area identified on the Glenamought River is on a pastoral area of land just upstream of Ballincrokig (**Figure 9**). It has the potential to store approximately 191,000m$^3$ at a max 3.5m depth of water stored**.** This would provide a significant reduction in the peak flow of the 1 in 100 year design flood event.

The potential storage area is located in an area of pastoral land just upstream of Ballincrokig. The construction works required are illustrated on **Figure 9** below and can be summarised as follows:

- Construction of an impounding embankment approximately 4m high, approximately 150m long. The embankment would incorporate a reinforced concrete flow control structure containing a hydrobrake. Note that a simple pipe through the wall is not feasible, as it would require more storage volume than would be practically achievable.
- On the Glenville Road, replace the existing masonry bridge with a new reinforced concrete culvert.
- A 120m length of the Glenville Road would need to be raised by an average of 0.75m
- Construct flood defence walls on either side of the Glenville Road just north of Ballincrokig, to prevent the stored water from inundating the road and the curtilage of the domestic properties.

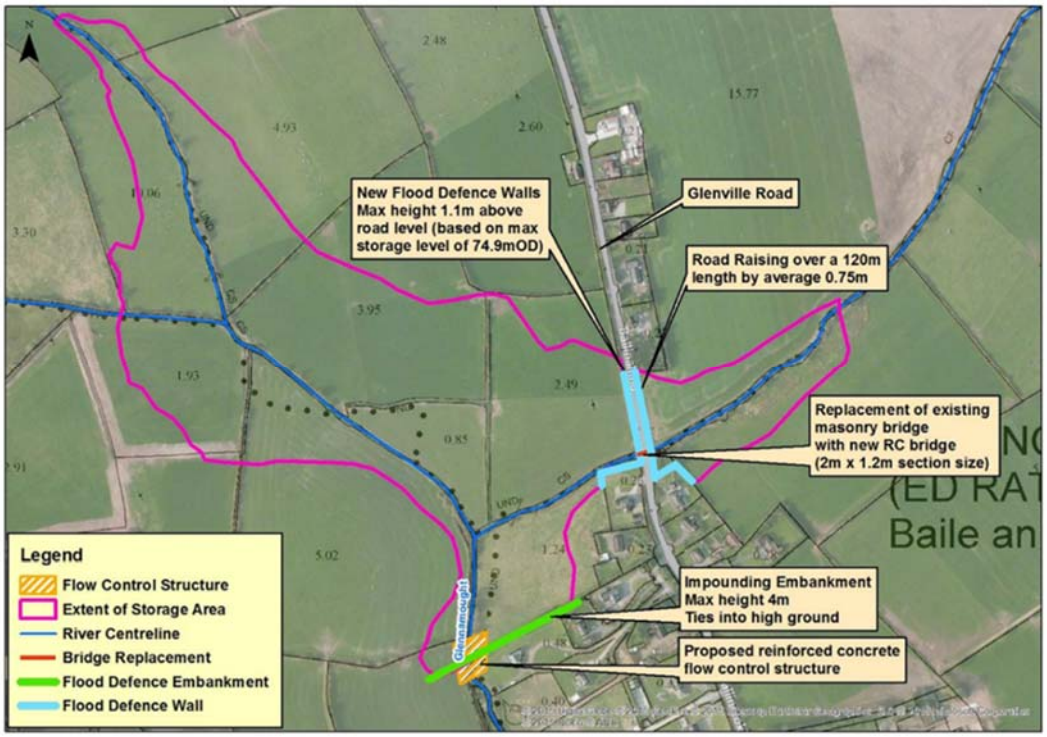


Figure 9 Possible Storage at Ballincrokig on the Glenamought

Due to the significant storage potential at Ballincrokig and its potential to reduce the peak flow of the design event by circa 10m$^3$/s, this option is deemed technically viable and is carried forward for further assessment.

### 4.2.3 Glen River

During the consultation process, the Blackpool Flood Committee identified a possible flood storage area on the Glen River in the Glen Recreational Park, just upstream of the North Ring Road (**Figure 10**). This possible location was therefore considered as part of the options assessment.


Figure 10 Possible Storage Area, Glen River

This measure proposes to install a flow control structure at the inlet to the existing sluice that conveys the Glen River under the North Ring Road. The sluice gate would be located at the downstream extent of the Glen River Park, just upstream of a 4m drop into a rectangular culvert. The flow control structure would limit the flow rate of the Glen River entering the culvert system which joins the Bride/Kiln culvert system at Madden's buildings. The restriction would cause water to pond behind the sluice gate and flood the park valley. The Glen has the potential to store up to approximately **96,000m$^3$** when water is impounded to a level of 35mOD (approximately 11m maximum depth of water). This is based on the assumption that that the existing North Ring Road embankment is structurally capable of withstanding the hydraulic load, which would require careful consideration if advanced further.

This measure would also require the raising/realignment of the pedestrian pathway which currently runs along the river bank.

This measure was analysed in the hydraulic model of the Bride/Glen river system. Whilst the measure would significantly reduce the peak flow in the Glen River, it was found that the resulting decrease in maximum flood level at Orchard Court was negligible. This is because the primary reason for elevated water levels at Orchard Court is because of insufficient capacity in the Bride Culvert upstream of the confluence with the Glen culvert which itself has ample capacity for a design event on the Glen. It is also worth noting that the peak on the Glen will typically occur several hours ahead of the peak on the Bride and therefore restriction of the peak flow on the Glen wouldn't be the primary objective.

For the above reasons, the installation of a flow control and a storage area at this location, whilst technically viable, would not yield sufficient benefit to justify such work at this time.

It is worth noting that in terms of adaptation for climate change, reduction of the peak flow from the Glen may warrant further consideration in the future given the finite capacity of the Kiln culvert system downstream of the confluence.

### 4.2.4 Combination of Storage Areas

A possible alternative to using a single storage area to achieve the necessary reduction in the peak flow would be to use a combination of two or more storage areas. A combination of storage areas would require an active control system to ensure that the timing of the releases from the storage areas can be managed, which would increases the complexity and cost of the option significantly. Since the required reduction could likely be achieved by one passive impoundment on the Glenamought, a combination of storage areas is deemed to be economically unviable.

Furthermore, lack of historical gauged data on spatial variation of rainfall would also limit the ability to optimise the design of such a solution.

## 4.3 Direct Flood Defences

This measure involves the construction of direct defences along the sides of the existing river to contain peak flood flows within the river channel. Direct defences have been considered at the following locations:

A. Lower Killeen's Road
B. North Point Business park
C. Commons Inn
D. Dulux Paints Factory
E. Orchard Court

These measures are described in detail hereunder.

### A. Direct Defences, Lower Killeen's Road

The hydraulic model results show that there is one domestic property at risk adjacent to the Bride River just upstream of the N20 road. The direct defence option at this location would be to construct a new flood defence wall around the property as shown in **Figure 11** below.

Access to the agricultural land north of the property will also be required and would likely be provided by way of a ramped access.

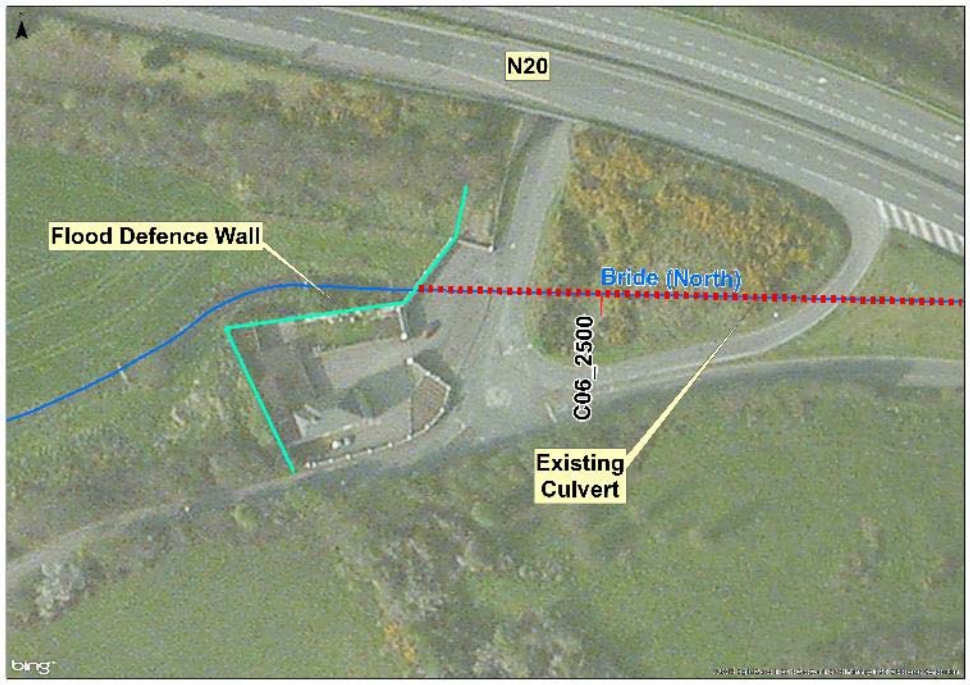


Figure 11 Direct Defences, Lower Killeen's Road

## B. Direct Defences, North Point Business Park

During the 2012 flood event, properties at North Point Business Park were inundated directly from the Glenamought Stream. Flood waters rose above both the left and right banks and flowed overland towards the properties. The direct defence option at this location would consist of new flood defence walls along both banks of the Glenamought between the access to North Point Business Park (chainage C08_75) and just upstream of the residential properties off the Old Mallow Road (chainage C08_225). **Figure 12** below shows these defences.

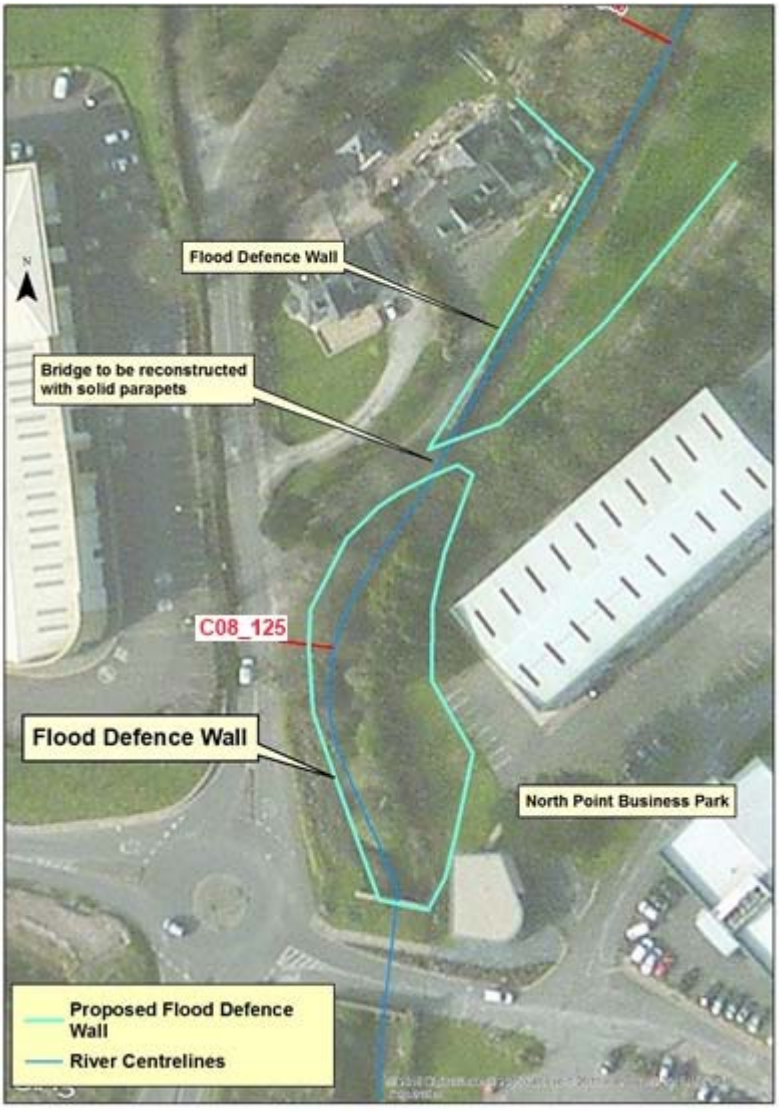


Figure 12 Direct Defences, North Point Business Park

## C. Direct Defences, Commons Inn

The Commons Inn Hotel was inundated during the June 2012 event with flood water entering the premises from the car park at the northern end of the property. The properties immediately downstream on the right bank were also flooded.

It is proposed to provide direct defences on the right bank to the rear of the Commons Inn and between the properties downstream of the Common's Inn along the N20. **Figure 13** below shows these defences.

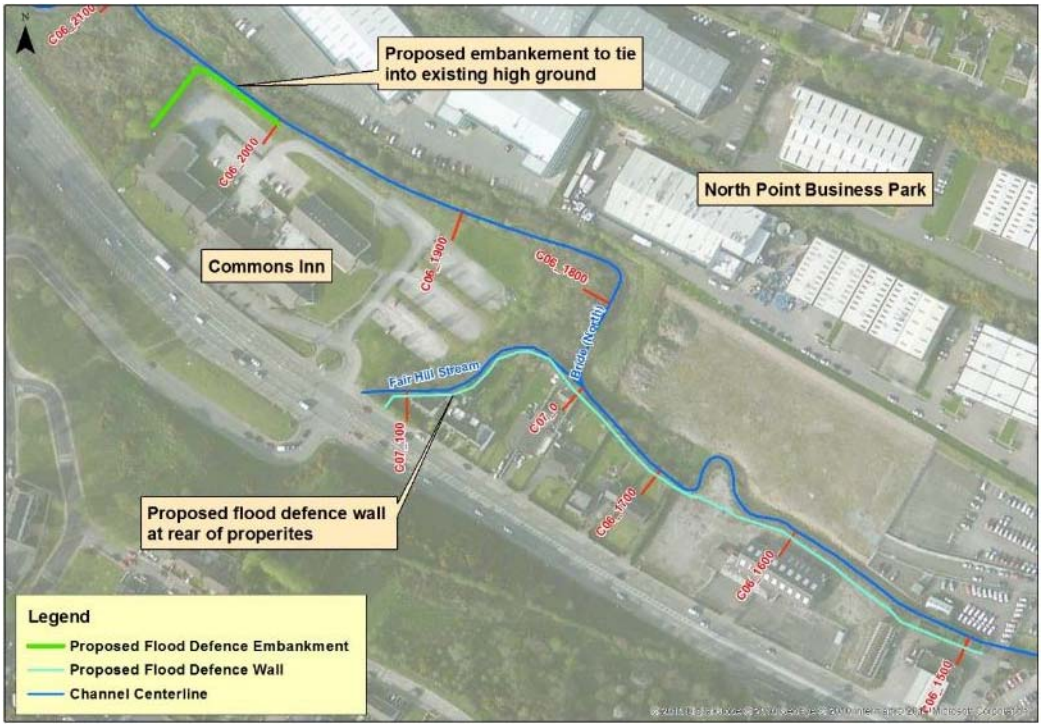


Figure 13 Direct Defences, Commons Inn

## D. Direct Defences, Dulux Paints Factory

The Dulux Paints factory premises were flooded by the June 2012 event, where flood water over topped the right-bank mid-way through the site and inundated the premises. The defence option here involves the construction of direct defences along both banks of the channel, which would likely take the form of extending and/or strengthening the existing RC walls. This will also involve incorporating and building upon a length of existing flood defence wall constructed since 2012. See **Figure 14** below.

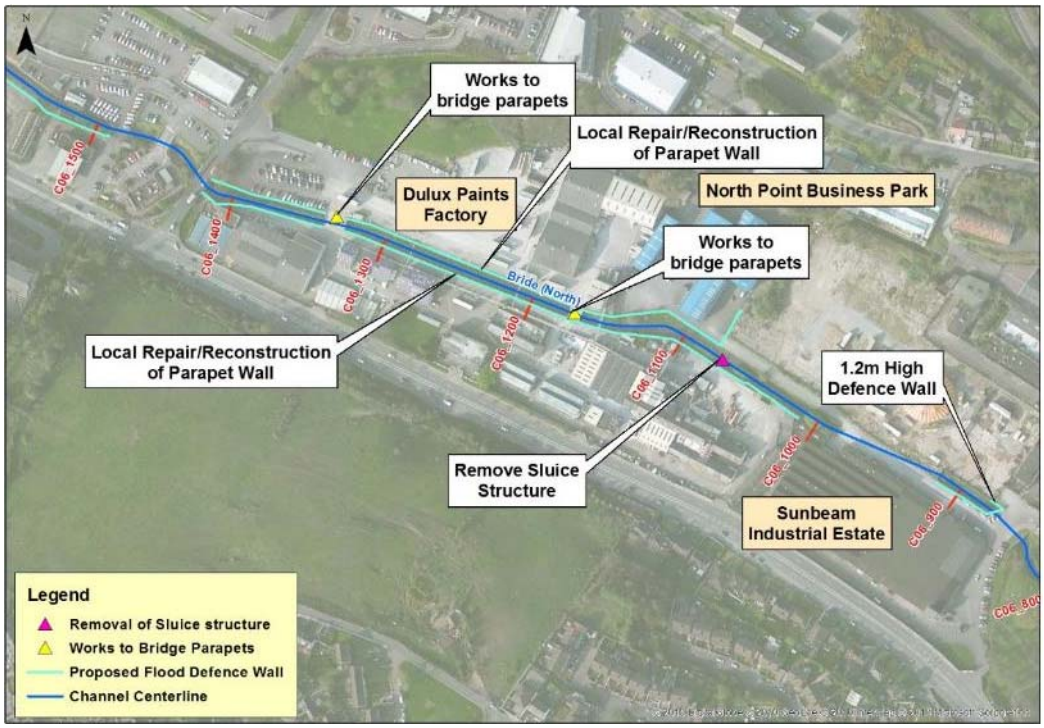


Figure 14 Direct Defences, Dulux Paints Factory

## E. Direct Defences, Orchard Court

The primary mechanism of flooding in Blackpool is as a result of flow spilling out over the low left-bank of the Bride along Orchard Court. Therefore, it is proposed to install a direct defence along the length of the left-bank and to replace the old masonry walls on the right bank with formal defences.

**Figure 15** below illustrates the extent of the potential direct defences at Orchard Court.

For this option to be viable as a standalone measure, it would be necessary for the new flood walls to be up to 2.5m high above existing ground levels. Therefore, the visual impact of this measure would be very significant, if adopted.

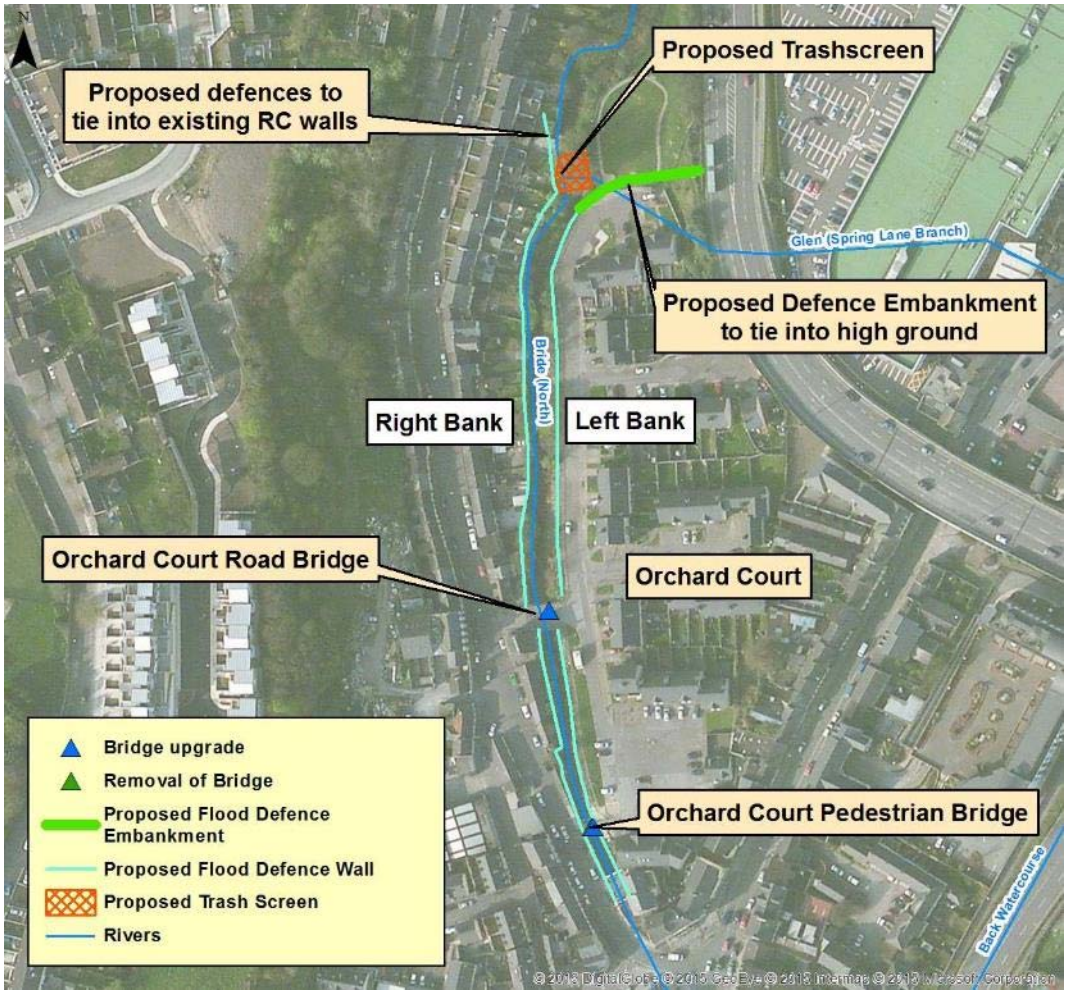


Figure 15 Direct Defences, Orchard Court

## 4.4 Culverting of Open Watercourses

This measure involves the culverting of existing open channel sections, thus containing flow within an enclosed system and avoiding the requirement for direct defences. Such a measure will only be feasible where sufficient space is available to install a sufficiently large culvert to convey the flow and/or where the installation of such culverts does not result in unacceptably high levels upstream.

Culverting of open watercourses was considered at the following locations:

A. Through Orchard Court

B. Adjacent to Blackpool Church.

These measures are described in detail hereunder.

### A. Culverting Bride North River, Orchard Court

An alternative to constructing defence walls through Orchard Court would be to culvert the River Bride along the same length (approximately 280m). An associated headwall structure and local defences would also be required at the upstream end to prevent floodwater overtopping and bypassing the culvert. This measure would also minimise the risk of blockage due to illegal dumping. See **Figure 16** below.

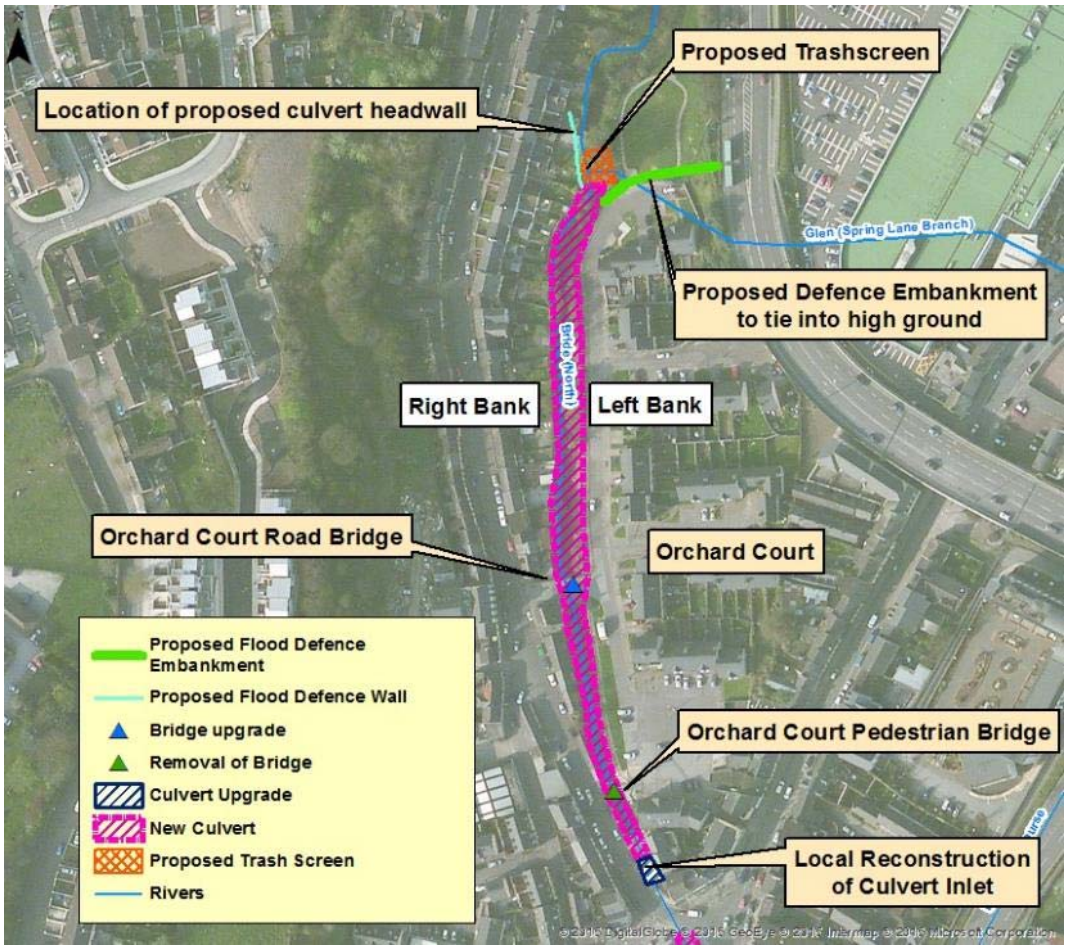


Figure 16 Culverting Bride North River, Orchard Road

## B. Culverting Bride North River, Blackpool Church

The existing open watercourse at Blackpool Church allows over topping of the channel during flood events. It is proposed to culvert the short existing open channel section section between the Orchard Court culvert outlet and the Blackpool Church inlet. This would keep all flow contained within the culverted system and prevent blockage risk from illegal dumping at this location. See **Figure 17** below.

It should be noted that this open channel section allowed overland floodwaters to re-enter the Bride during the 2012 event and thus reduced the depth of flooding in Blackpool village. Culverting of this section would remove this relief mechanism and so it would need to be undertaken in conjunction with alternative local surface water drainage measures.

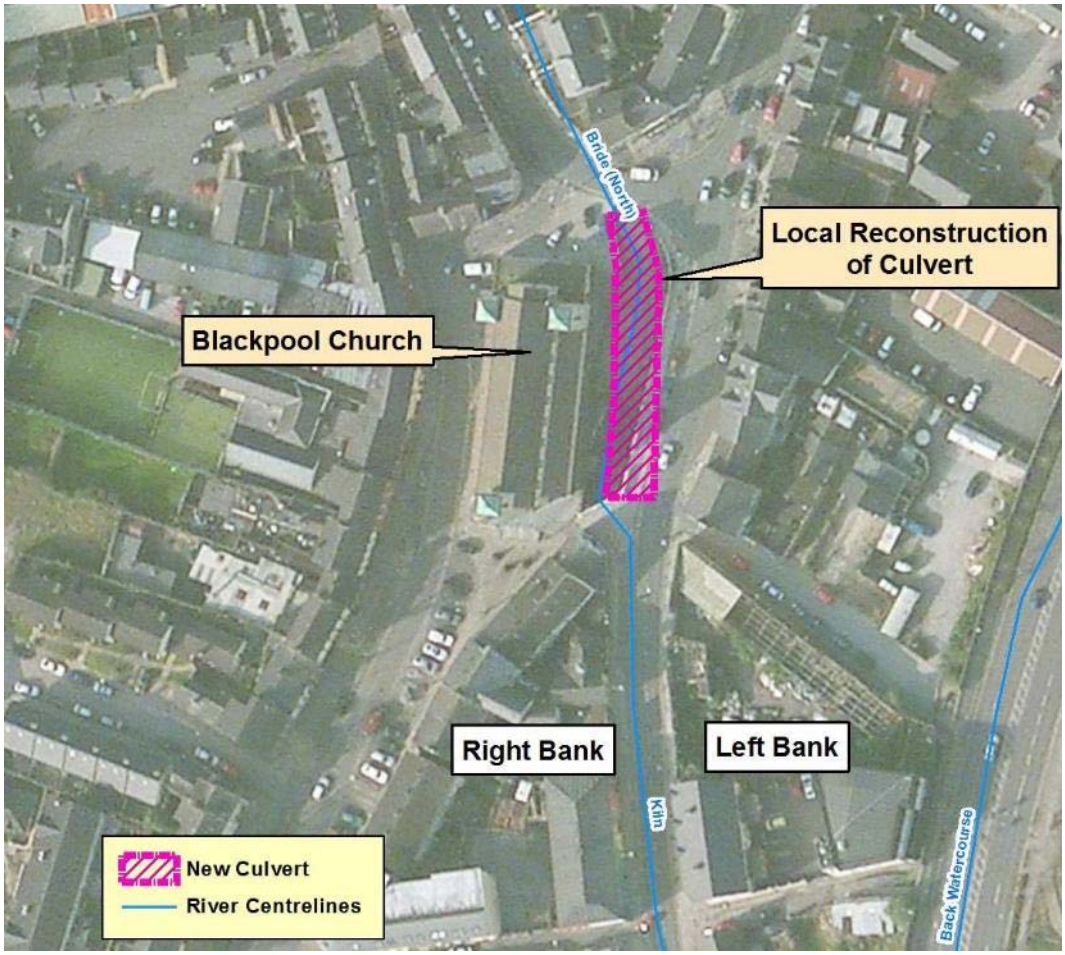


Figure 17 Culverting Bride North River, Blackpool Church

## 4.5 Temporary Diversion (or Flood Relief) Channels or Culverts

This measure involves diverting excess flood flow away from the main river channel during the design flood event. It involves constructing a new channel (or culvert) that remains dry in low flow conditions. When the water level rises above a certain threshold, water spills into the diversion channel/culvert and is conveyed downstream, separately to the main channel. At a suitable point downstream, the diverted flow re-joins the main river.

The potential for diversion channels or culverts for the Bride through Blackpool was reviewed. Due to the narrow, steep sided valley and the densely urbanised nature of Blackpool, no feasible open cut route could be identified. To feasibly construct a diversion culvert would require extremely deep excavations (>10m), tunnelling, or demolition of existing properties, to open up potential routes. The cost of such extreme measures would be prohibitively high.

## 4.6 Conveyance Improvements

Along the length of the Bride North River, certain sections constrict the river and thus increase upstream flood levels. If conveyance improvement measures were undertaken, these could result in an appreciable reduction in water levels.

The potential measures identified and considered included:

- Enlargement of the channel cross section along certain lengths.
- Replacement or removal of bridges and other structures that significantly elevate water levels in flood conditions.

The measures outlined below were considered to be potentially feasible:

A. Bridge Upgrades, Commons Road
B. Winter Channel, Commons Road
C. Bridge Improvements, Orchard Court
D. Culvert Inlet Realignment, Orchard Court
E. Culvert Inlet Realignment, Blackpool Church
F. Culvert Upgrade from Orchard Court to Maddens Buildings
G. Junction Realignment, Madden's Buildings
H. Culvert Remediation at Brewery Culvert Inlet

These are considered in more detail below.

## A. Bridge Upgrades, Commons Road

Several existing bridges along Commons Road were found to be under-capacity during the design flood event, and therefore causing significant backwater effects along the reach. These bridges are shown on **Figure 18** and listed below:

- Masonry bridge on the Glenamought River at the entrance to a domestic property (chainage C08_164)
- Pipe culvert on the Glenamought River at the entrance to North Point Business Park (chainage C08_70)
- Masonry arch bridge over the Bride River at Fitz's Boreen (chainage C06_1420)

Upgrading of these bridges would also help to minimise the risk of debris blockage.

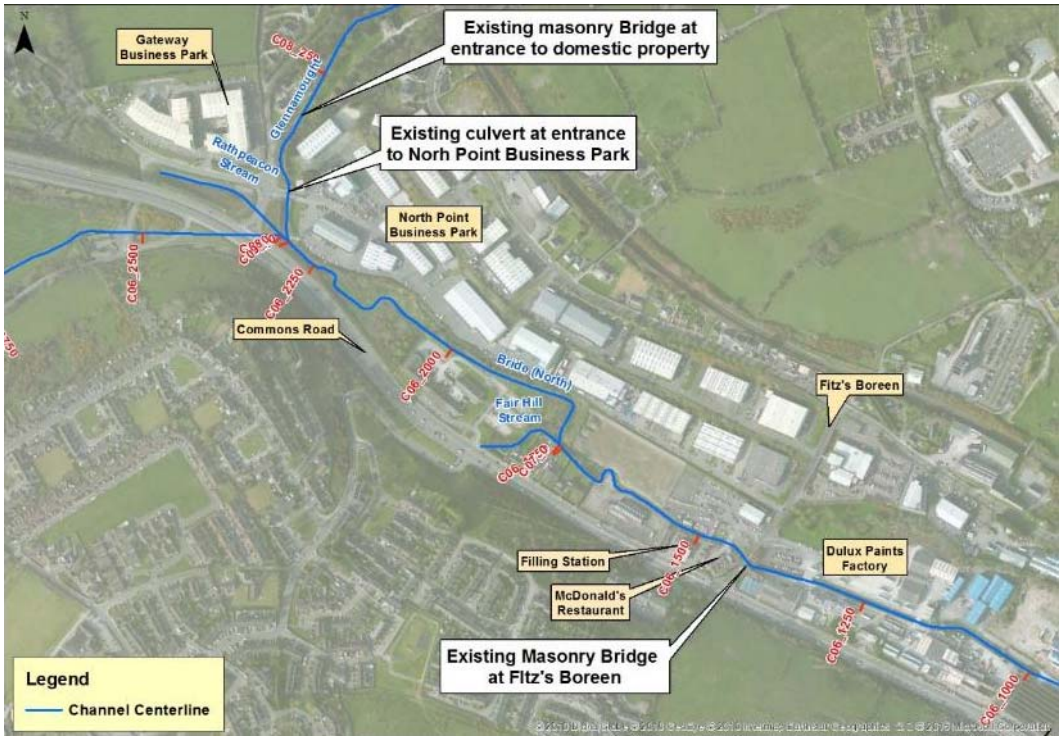


Figure 18 Commons Road Bridge Upgrades

## B. Winter Channel, Commons Road

A series of sharp bends in the Bride channel contribute to elevated flood levels along the Commons Road. This is because the water velocity is abruptly slowed at each of these bends. It would be beneficial if the route of the channel could be softened somewhat to allow for smoother transitions. It is proposed to introduce a 'winter channel' to complement the existing channel just downstream of the commons Inn, to help with higher-order flows by cutting a secondary flow route into the existing bank. In normal flow conditions, the river would be confined to the 'low-flow' or 'summer channel', however during periods of high flow the winter channel would provide additional capacity. The magnitude of level reduction would be dependent on the required size of the winter channel. **Figure 19** below shows a typical cross section of the proposed winter channel and **Figure 20** illustrates the proposed location of the winter channel at Commons Inn.

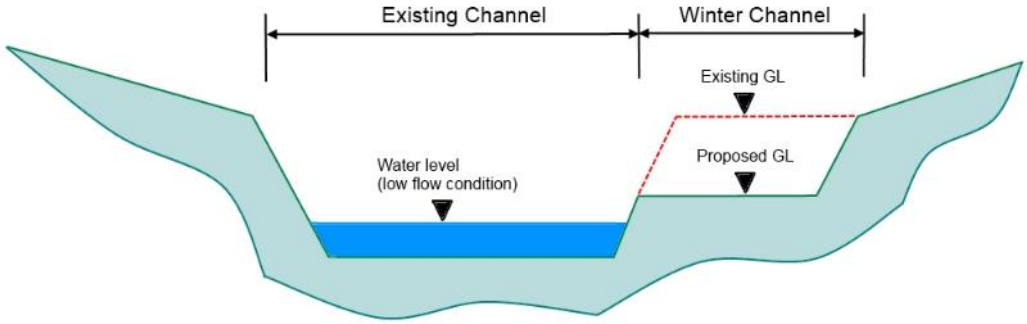


Figure 19 Typical Winter Channel Section (looking downstream)

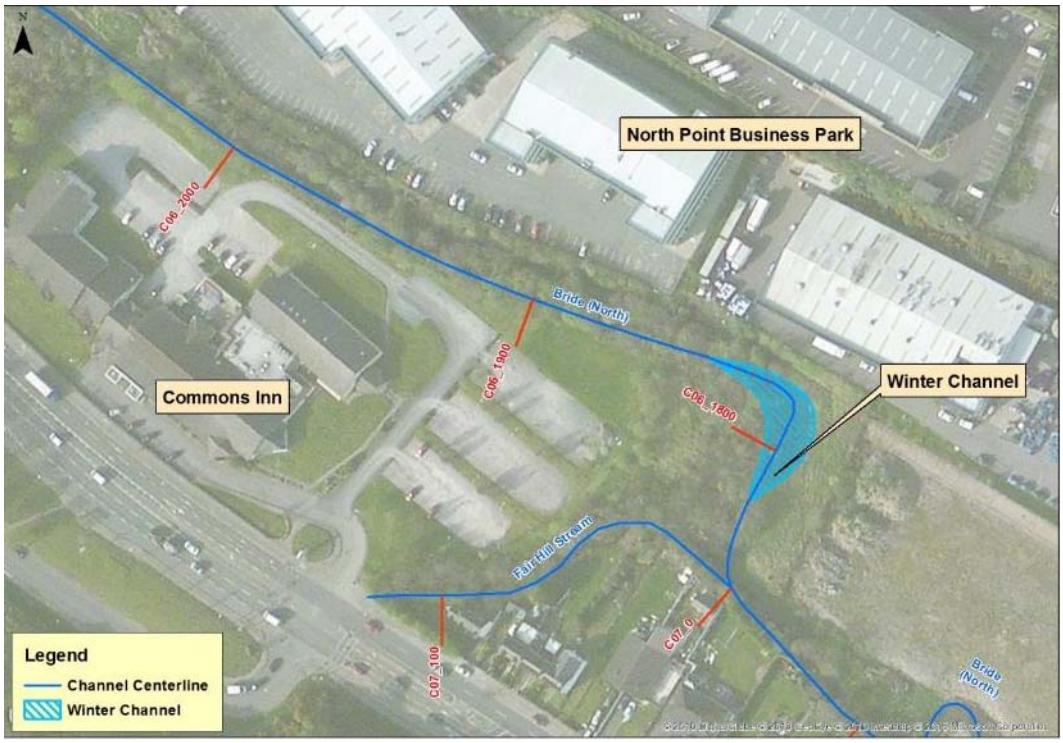


Figure 20 Winter Channel Plan

## C. Bridge Improvements, Orchard Court

The existing Orchard Court road bridge has a culvert soffit almost 1m below the road level. The low culvert soffit can lead to elevated water levels upstream and exacerbate flooding in Blackpool. As part of this measure the existing road bridge would be replaced by a bridge with a higher soffit.

The existing pedestrian bridge at the downstream end of Orchard Court was also found to restrict conveyance of the Bride during flood events. As part of this measure, the pedestrian bridge would be removed. This would have the effect of further reducing upstream flood levels. Pedestrian access to Orchard Court would still be available from the Commons Road via the road bridge, and also from Thomas Davis Street.

**Figure 21** illustrates the location of the existing bridges in Orchard Court.

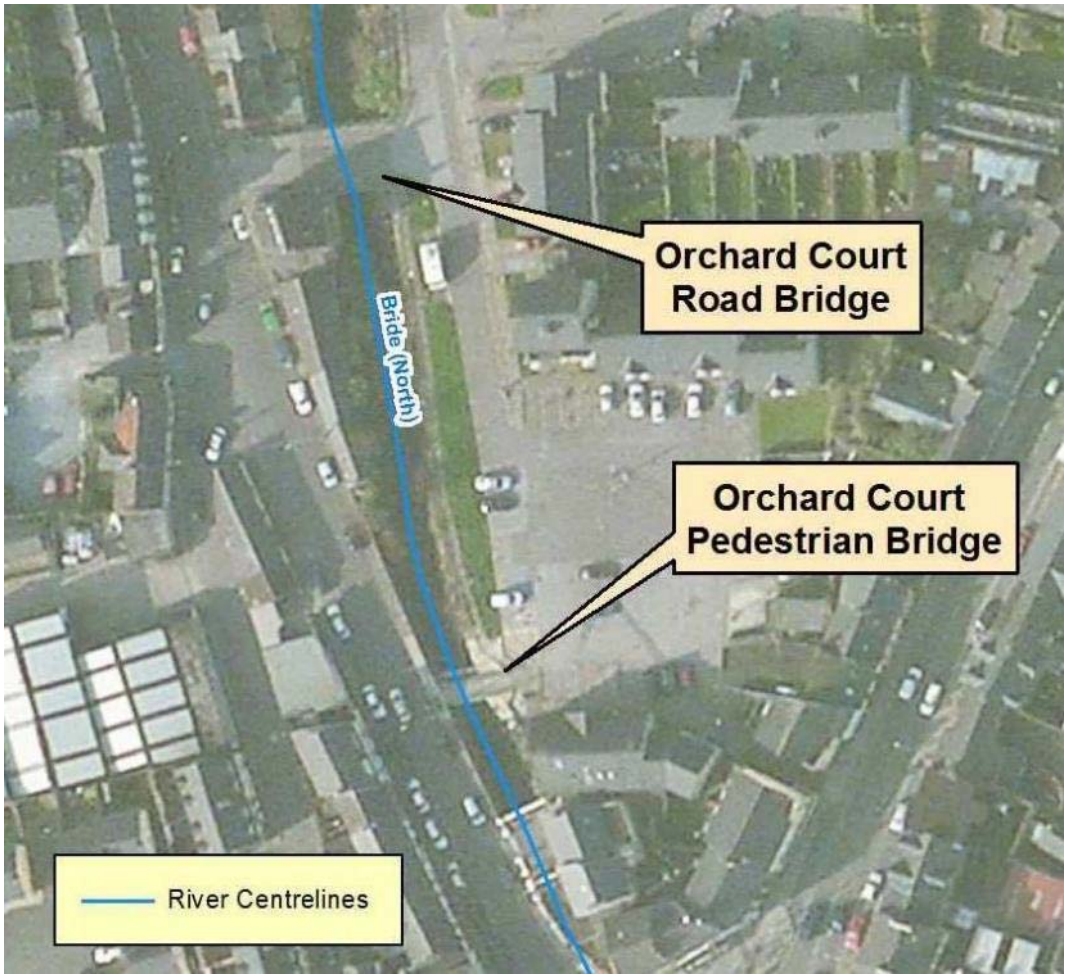


Figure 21 Orchard Court Bridges

## D. Culvert Inlet Reconstruction, Orchard Court

The existing inlet to the Bride culvert just downstream of Orchard Court has a locally smaller cross section than the rest of the culvert system downstream, which increases the predicted flood levels upstream. Therefore, it is proposed to remove this restriction by locally reconstructing the inlet to increase the culvert height from 1.6m to 2.1m. The location of the culvert inlet is shown in **Figure 22** below.

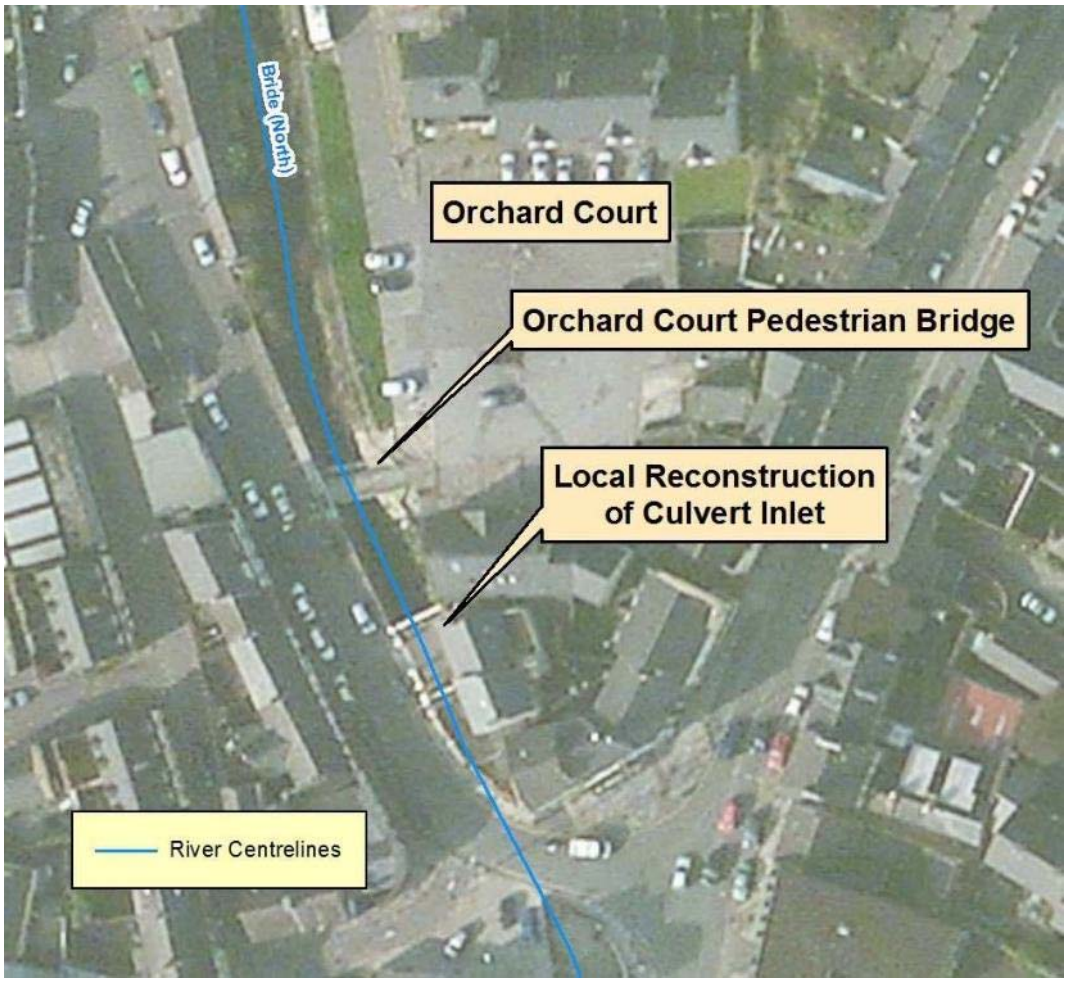


Figure 22 Reconstruction of Culvert Inlet at Orchard Court

## E. Culvert Inlet Realignment, Blackpool Church

Another source of head loss in the system is the existing culvert inlet at Blackpool Church. At present, the Bride flow must make two sudden turns as it enters the culvert, which cause significant turbulence and head losses. There is also a concrete block at the base of the culvert on the right-hand side that causes localised head losses. It is proposed that the inlet be straightened to provide for an easier transition into the culvert. This would involve beginning the channel turn earlier than the current scenario, as shown in **Figure 23** below.

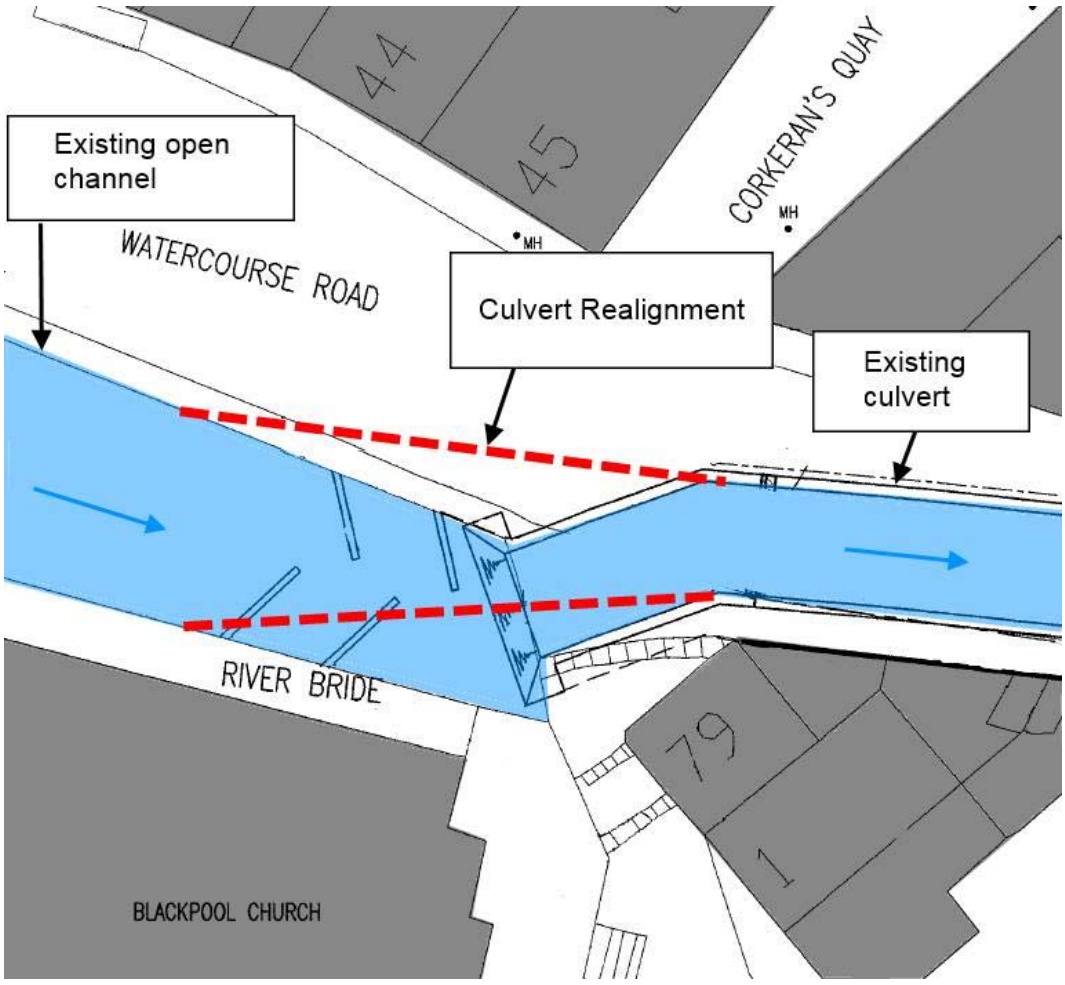


Figure 23 Realignment of Culvert Inlet at Blackpool Church

## F. Culvert Upgrade from Orchard Court to Maddens Buildings

The existing Bride culvert between Orchard Court and Maddens Buildings is predicted to become surcharged during the design event. This significantly elevates water levels upstream in Orchard Court, and also prevents surface water drainage in Blackpool from entering the culvert.

This measure would involve upgrading the existing culvert over its full length, including realignment of the culvert junction at Maddens Buildings. This measure would significantly reduce flood levels upstream in Orchard Court, and would ensure that the culvert itself would not be surcharged during the design event. There would be significant disruption to traffic and businesses in Blackpool during construction of this measure, and the cost is likely to be high.

## G. Culvert Junction Realignment, Madden's Buildings

At Madden's Buildings (approximately 200m downstream of Blackpool Church, at the junction of Watercourse Road and the Blackpool bypass), there is a junction in the Glen/Bride/Kiln (GBK) culvert system. The arrangement and split of flows between the arms of the junction is complicated and was subject to detailed analysis (including flow monitoring) as part of the hydraulics study for this scheme.

Up until recently, there was a diversion block at the entrance to the Brewery culvert that limited flow into the culvert and diverted more flow toward the Phase 4 GBK conduit. However, it was particularly effective in catching debris and was removed in the summer of 2014. The flow monitoring survey concluded that upon its removal, approximately 55-70% of higher-order flows were sweeping directly into the Brewery culvert, with the remainder carrying on to the Phase 4 GBK conduit. During the hydraulic analysis, it was established that the complicated nature of the culvert junction (and the resulting hydraulic inefficiency) is a contributing factor to elevated flood levels at Blackpool Church. It is predicted that the series of turns increase water levels in the junction by approximately 100-200mm. Therefore, optimising this junction would reduce flood levels upstream.

This measure proposes to adjust the junction geometry so that the Bride's transition into the Kiln culvert is straighter. The revised geometry of the junction would also be designed to limit flow into the existing Brewery culvert to prevent the Brewery culvert surcharging during the design event as it is an existing bridge arch construction and therefore has very limited structural capacity to resist surcharging. The flow percentage mentioned above is simply not advantageous for the continued service life of the Brewery culvert. Initial hydraulic modelling has suggested that 9.5m$^3$/s is a reasonable limiting flow for the Brewery culvert as surcharging is prevented. See **Figure 24** below.

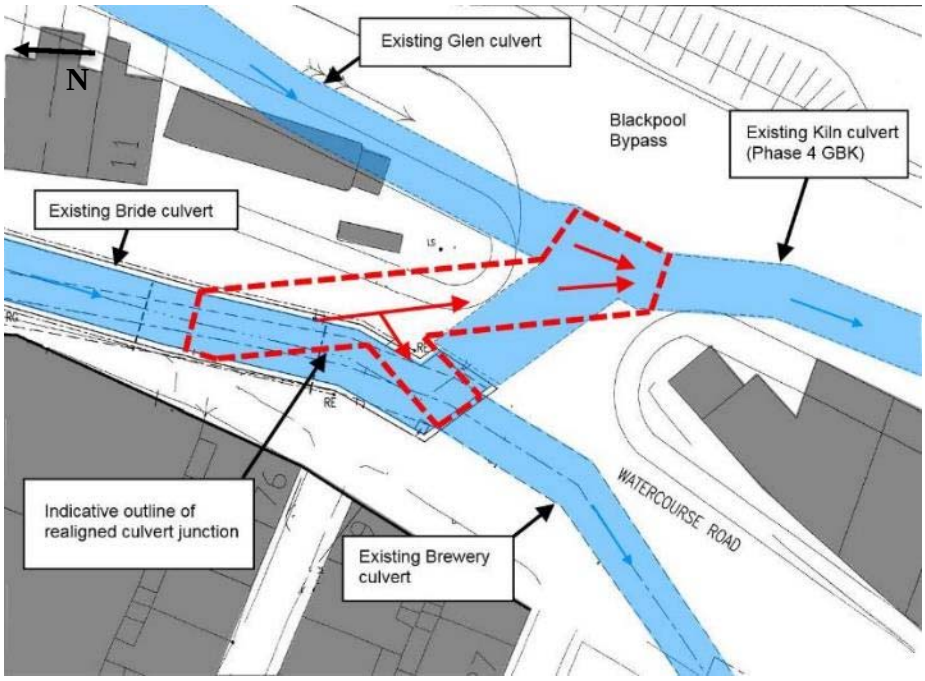


Figure 24 Realignment of Culvert Junction, Madden's Buildings

## H. Culvert Remediation at Brewery Culvert Inlet

It is anticipated that the Madden's Buildings junction will be surcharged as most options involve allowing a greater percentage of the design flow rate to drain to this point as a result of removing potential floodplain i.e. Commons Road, Orchard Court etc. Therefore, the structural integrity of the Brewery culvert will have to be reinforced at its inlet to ensure safe operation during flood events.

## 4.7 Measures to Control Debris

Blockages of hydraulic structures by water-borne debris is known to have been a mechanism of flooding during past flood events in the catchment. Measures to alleviate this risk include the construction of suitably sized structures in the channel to capture the debris at a point upstream of where it could cause major issues such as blockage of a bridge or culvert barrel.

While this measure would not alleviate flood risk by itself, the option was reviewed as a potential additional measure to minimise any residual risk following construction of the scheme.

### A. Proposed Coarse Screen at Kilnap Viaduct

To reduce the amount of debris potentially arriving at any trash screen upstream of the Orchard Court culvert, and to reduce the required trash screen area to a practically achievable and visually acceptable scale, it is proposed to include a coarse screen just upstream of Kilnap Viaduct as shown in **Figure 25** below.

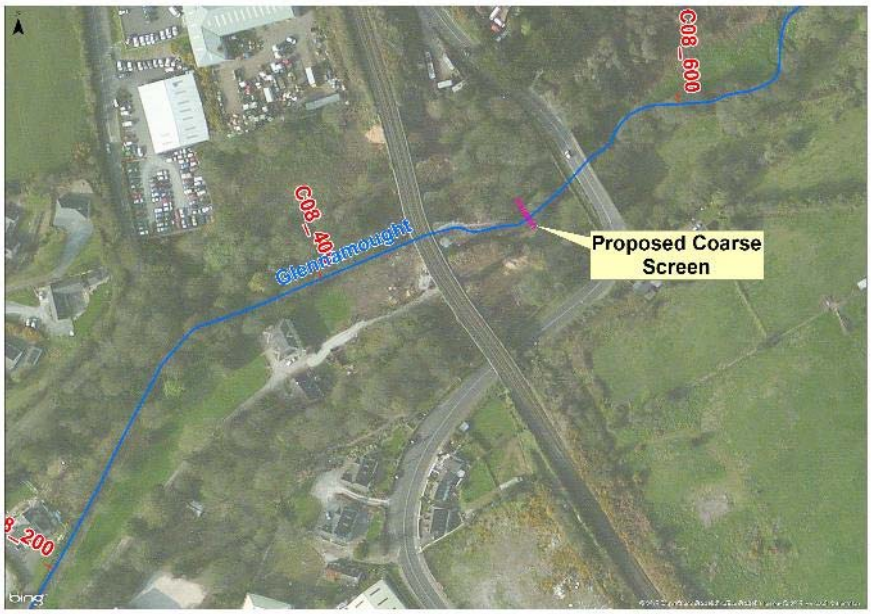


Figure 25 Location of Proposed Coarse Screen just upstream of Kilnap Viaduct

This was the location of an historic mill and therefore access to this location can be easily achieved by upgrading the existing access route shown in Figure 26.

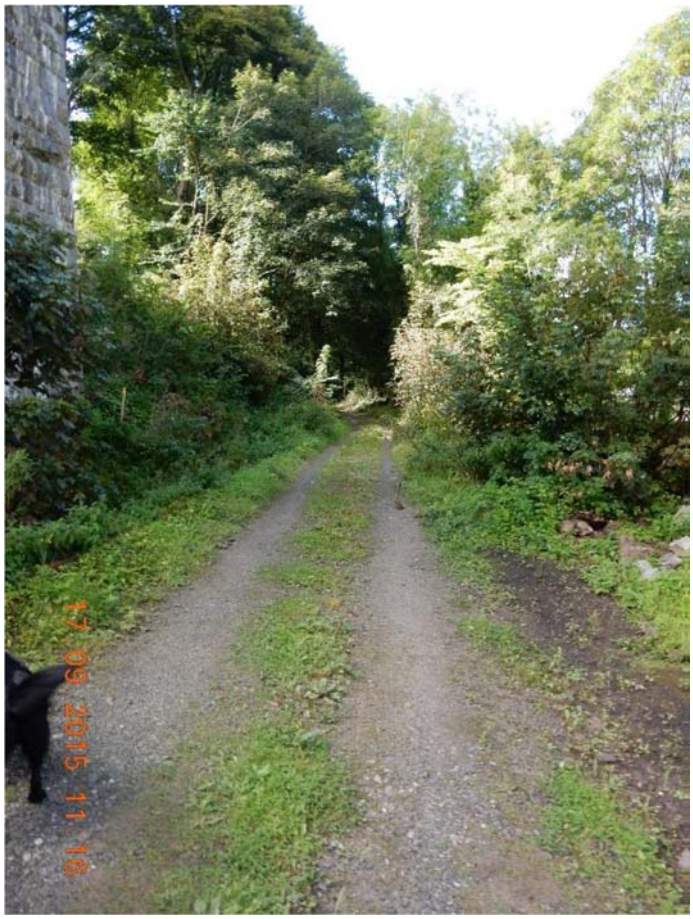


Figure 26 Existing access road to location of proposed coarse screen at Kilnap Viaduct

**Figure 27** shows how a course screen area of 40m2 to 60m2 can be achieved whilst also allowing for 1m of overtopping during high flood levels. In the event of blockage, there is ample space for the river to naturally flow over and around the screen without the risk of flooding nearby properties.

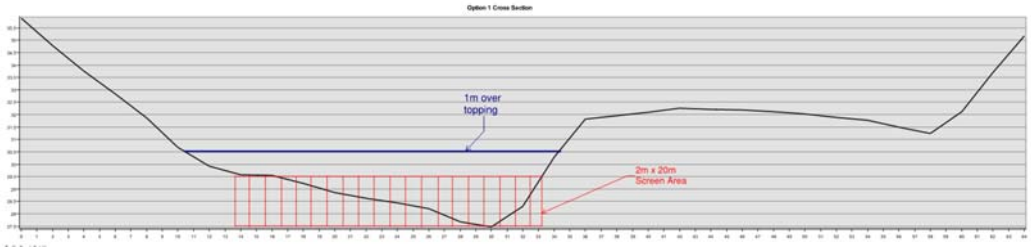


Figure 27 Cross Section of proposed coarse screen

## B. Replacement of Coarse Screen on Bride

It is also proposed to replace the existing coarse screen which exists on the Bride just upstream of its confluence with the Glenamought as shown in **Figure 28** below.

Figure 28 Existing Coarse Screen on Bride upstream of Glenamought confluence

## C. Trash Screen upstream of Orchard Court Culvert

A trash screen is proposed at the inlet to the proposed Orchard Court culvert. The trash screen would have two purposes.

Firstly it would be designed to restrict the transport of large items down the river channel which could potentially cause a blockage of the channel or damage the culvert. The trash screen would be located in a predominantly urban area with both residential, commercial and light industrial sites along the upstream river reach. Therefore, large manmade items as well as natural sediment and vegetation from the upstream rural areas are likely to be intercepted by the trash screen.

The secondary function of the trash screen is to act as a security screen to restrict unauthorised access to the defended reach. This is particularly important as the inlet to the culvert is in a residential area where there is a high risk of unauthorised entry.

It is important that the relevant authority maintains these screens regularly and in particular in advance of any forecasted rainfall event.

A preliminary sizing based on the Environment Agency's Trash & Security Screen Guide, 2009 suggested that a useable screen area of approximately **100m$^2$** would be required upstream of the Orchard Court culvert.

This area assumes the incorporation of coarse screens on both the Bride and the Glenamought before their confluence.

This measure was considered feasible for Blackpool and is assessed further in the detailed option selection.

### D. Trash Screen or Coarse Screen at Spring Lane

During the 2012 flood event, the existing trash screen on the Glen culvert inlet at Spring Lane became blocked and overflowed, contributing to the flooding in Blackpool village. The existing screen is shown in **Figure 29** below.

A possible solution here would be to remove the existing screen and install a new screen designed in accordance with the latest guidance. This screen would likely have a larger area than existing, would facilitate raking debris over the top of the sloping stages and would also include accessible working platforms.

Given the relatively remote location of the screen, it is envisaged that some water level monitoring and CCTV cameras would be necessary here also.

An alternative solution here would be to remove the screen entirely. This may be justified since there is also an existing screen a short distance upstream in the Glen Recreational Park. Therefore the length of channel which could be contributing to the debris load at the existing Spring Lane screen is only approximately 250m. If the trash screen were to be removed, additional fencing may be required to ensure that the public could not gain access to the culvert.

Further detailed assessment is required to determine whether a screen is required at this location or not and is discussed later in this report.

Figure 29 Existing trash screen on the Glen River at Spring Lane

## 4.8 Sediment Management

As large volumes of sediment have historically built up within the culvert system downstream of the church, it is considered that active management of sediment upstream of the culvert system will be an essential and integral part of the solution for Blackpool.

It is proposed to manage sediment by the incorporation of a sediment trap just downstream of the Dulux Paints factory.

The sediment trap will help control the sediment volume downstream by widening the channel, and accordingly reducing velocities allowing sedimentation carried by the river to settle out. This trap will have direct access for maintenance.

Figure 30 below shows the proposed location of the primary sediment trap at Dulux.

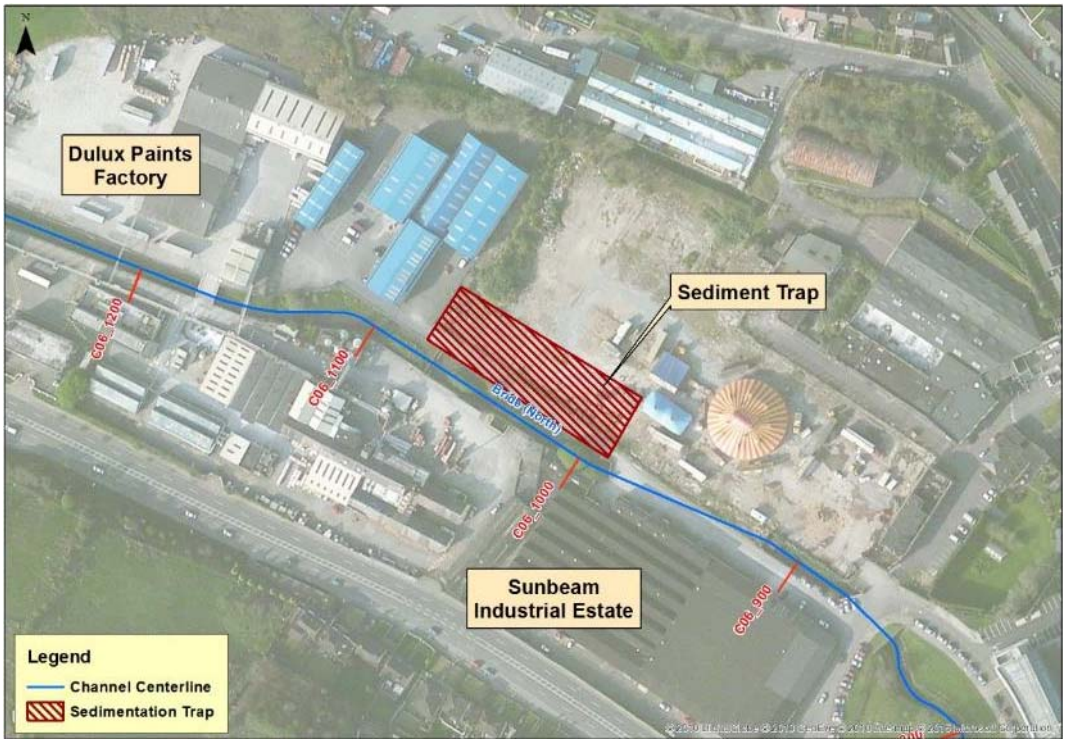


Figure 30 Primary Sediment Trap at Dulux

Whilst the above is considered to be the primary mechanism for sediment management, the naturalization and reconnection of the floodplain upstream of the Commons Inn could also offer some natural control of sediments arriving at the sediment trap and act as a secondary sedimentation area.

**Figure 31** below shows the provisional location of this potential sedimentation area upstream of the Commons Inn.

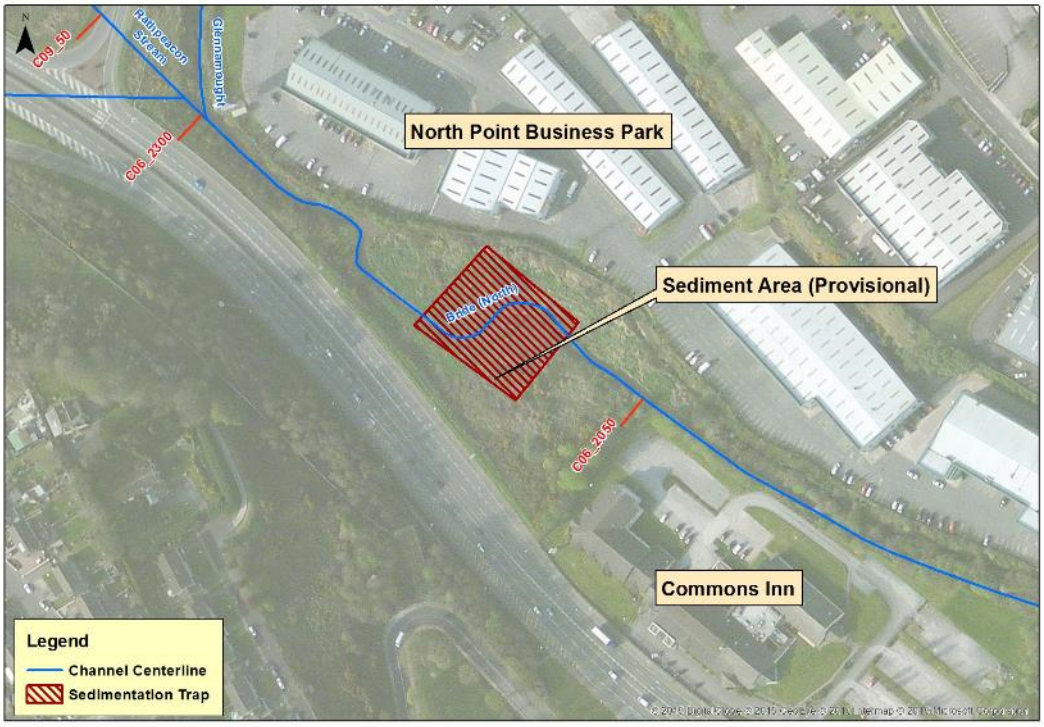


Figure 31 Provisional Secondary Sedimentation Area

The use of this naturalisation of the river upstream to assist in sediment management would be provisional and subject to post scheme monitoring. It will only be implemented if it considered necessary/beneficial having monitored the effectiveness of the primary sediment trap.

These measure were considered feasible for Blackpool and are assessed further in the detailed options selection.

## 4.9 Pumping

This measure involves pumping excess flood flow away from the main river channel during the design flood event. The works would involve the construction of a pumping station upstream of the area at risk, which would pump flood waters through a rising main before re-entering the river channel downstream of the area at risk.

The predicted 1 in 100 year flow on the Bride River at Blackpool Village is approximately 34m³/s.

As noted, the threshold of flooding in Blackpool, is circa 22m$^3$/s. To reduce the peak flow below this threshold would require a peak pump rate of up to 10m$^3$/s.

Whilst the above may be technically feasible, it would require the construction of a large pumping station and rising main with an estimated cost of circa €2m to €3m.

As the areas at risk cover an extended length and given the urbanised nature of the area, finding a suitable location for such a rising main would prove extremely difficult.

As well as the high capital cost, this measure would generate high ongoing maintenance costs.

This measure would also likely have significant negative environmental and social impacts.

Based on the above it is considered that pumping is not an economically viable option and it is therefore not considered further in the context of a primary solution for Blackpool.

However, localised pumping would still be required in areas where surface run-off would be predicted to pond behind flood defences or adjoining surcharged culverts during a flood event.

# 5 Development of Flood Relief Options

## 5.1 Introduction

In order to arrive at a preferred solution, five options comprising a number of the measures outlined in Chapter 4 have been developed to a sufficient level of detail to allow a detailed appraisal be undertaken.

The flood relief options taken forward for further development are:

- **Option 1** – 'Do-Minimum'.
- **Option 2** – Ballincrokig flood storage, combined with conveyance improvements and direct defences at Common's Road/Blackpool.
- **Option 3 –** Conveyance improvements and direct defences (with high walls in Orchard Court).
- **Option 4 –** Conveyance improvements and direct defences (with culvert through Orchard Court).
- **Option 5 –** Conveyance improvements & direct defences (culvert replacement from Orchard Court to Madden's Building).

All of the above options would also incorporate debris control and sediment management measures as outlined above.

For the purposes of the initial development and assessment of options, a fixed freeboard of 500mm on all direct defences was assumed. This assumption will be tested by undertaking a more detailed freeboard analysis on the preferred option once it is selected. This approach is discussed later in this report.

The hydraulic performance of each option can be examined in greater detail by reference to the hydraulic long sections provided in Appendix C of this report.

## 5.2 Option 1 – 'Do Minimum'

Refer to **Figure 32** and **Table 2** for a description of Option 1.

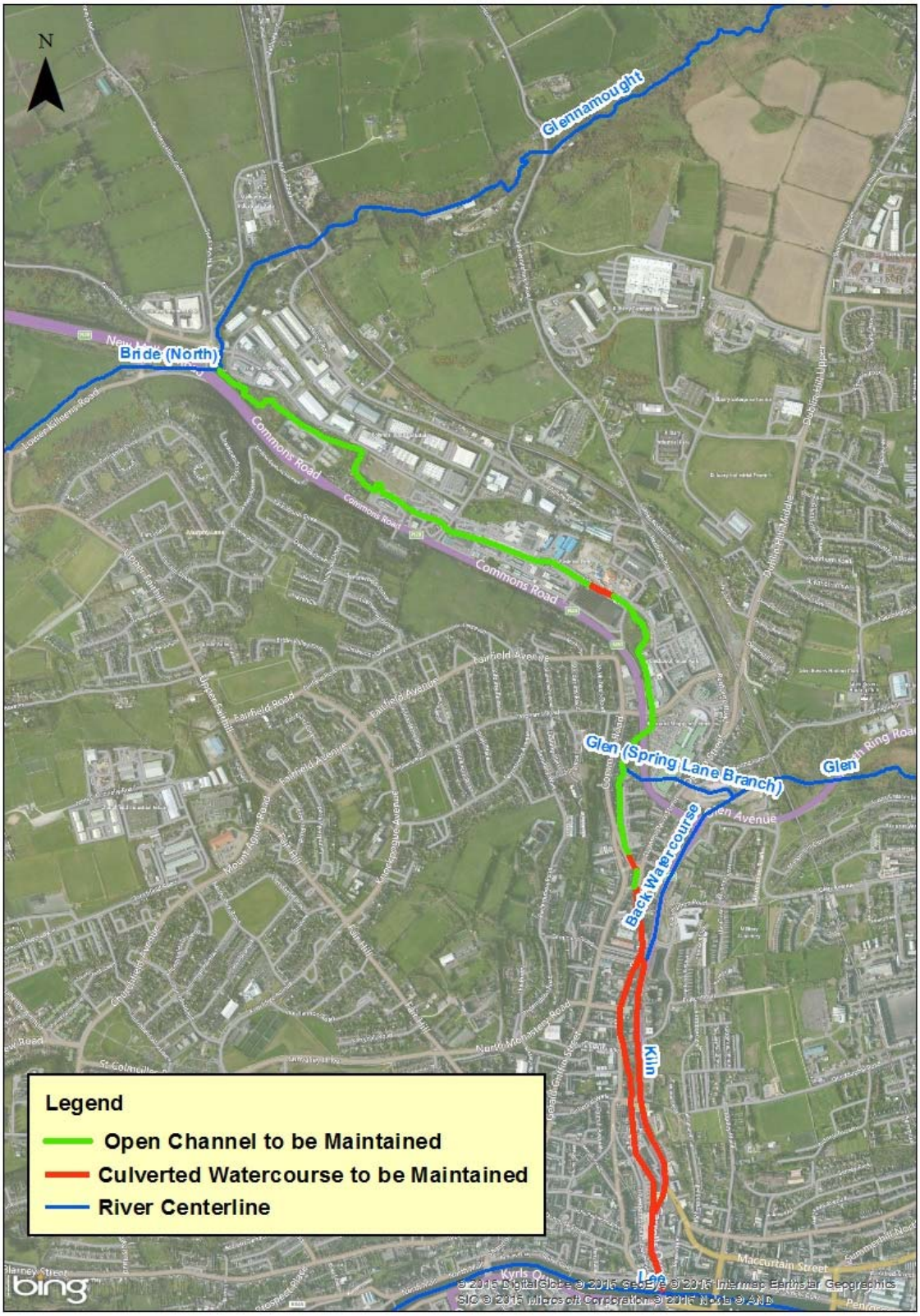


Figure 32 Extent of "do minimum" works

Table 2 Option 1-'Do Minimum' Summary

| Area | Measure category | Chainage | Location (and Total Length of Channel Affected) | Description | Comments |
|---|---|---|---|---|---|
| **ALL** | Maintenance | C06_2306 to C06_0000, C01_1180 to C01_0000, C02_0824 to C02_0000 | The Bride River from its confluence with the Glenamought River, downstream to its outfall to the River Lee (total length approximately 3470m). This measure also includes the Brewery Branch reach of the Kiln River (approximately 825m long) | Implementation of an organised channel maintenance programme throughout the reach with particular attention paid to locations where debris is likely to accumulate, such as at structures, sharp bends, culvert inlets etc. Programme to include checking and cleaning of culverted reaches. | |

## 5.3 Option 2 - Ballincrokig flood storage, combined with conveyance improvements and direct defences in Common's Road/Blackpool

Refer to **Figure 33**, **Figure 34**, and **Figure 35** and **Table 3** for a description of Option 2.