Oifig na nOibreacha Poiblí
The Office of Public Works

Lower Lee (Cork City) Drainage Scheme
(Flood Relief Scheme)

Options Report

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ARUP

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Office of Public Works

Lower Lee (Cork City) Drainage Scheme

Flood Risk Management Options Report

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1 Introduction

1.1 Context

There is a long history of flooding in Cork City and the River Lee valley. A number of severe floods have affected the city in the past. Since construction of the two dams at Inniscarra and Carrigadrohid in the 1950's, floods in Cork have generally been less severe although there has been frequent flooding of land, roads and small numbers of properties. The event of November 2009 was an exception, with major damage caused to commercial and residential buildings in Cork City.

The 2009 event heightened public awareness of the significant flood risk which exists in Cork City. The Office of Public Works (OPW) in partnership with Cork City and Cork County Councils have carried out a Catchment Flood Risk Assessment and Management (CFRAM) Study for the Lee Catchment. The Final Catchment Flood Risk Management Plan (CFRMP) was published in January 2014.

The Lower Lee Flood Relief Scheme is a key deliverable of the OPW's National Flood Risk Management programme. The OPW are advancing this scheme as part of its mandate as the lead agency for flood risk management in Ireland. It is developed in close co-operation with all key stakeholders, in particular; Cork City Council, Cork County Council and the ESB.

Arup in association with JBA Consulting were commissioned by the OPW to develop the Lower Lee Flood Relief 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 and
- Stage V - Handover of works.

This Options Assessment Report is produced as part of Stage I of the project and covers the area from Inniscarra Dam to Cork City. It follows on from work carried out both as part of the Lee CFRAM Study and work carried out to date by the design team for the Lower Lee Flood Relief Scheme. This report should be read in conjunction with the following:

- All Lee CFRAMS documentation and Report (http://www.opw.ie/en/leecframs

- Lower Lee Flood Relief Scheme (FRS) Constraints Study
- All documentation from the Emerging Preferred Options stage Public Information Day
- Lower Lee FRS Hydrology Report
- Lower Lee FRS Hydraulics Report
- Lower Lee FRS Phasing Report
- All Lower Lee FRS Exhibition Documentation

The above documentation is available to download from the project website at www.lowerleefrs.ie.

1.2 Scope of Report

The purpose of this report is to assess all of the viable flood relief options that could be implemented in the area from Inniscarra dam to Cork City and to outline the procedure of how the preferred option was developed and selected.

This procedure is outlined as follows:

- Review and consideration of the screening and assessment of possible flood risk management options undertaken as part of the Lee CFRAMS Study. (This included a Cost Benefit Analysis and Multi-Criteria Analysis).
- A fresh initial screening of an extensive list of possible flood risk management measures against a predetermined set of criteria, was carried out as part of the Lower Lee FRS in order to determine their viability.
- A technical assessment of the potentially viable flood risk management measures was undertaken.
- Potential flood relief options were developed using combinations of those flood risk management measures which were determined to be technically viable.
- These flood relief options were then subjected to a multi-criteria assessment consisting of technical, economic and environmental criteria, and a Cost Benefit Analysis to allow a preferred flood relief option to be selected.

1.3 Study Area

The River Lee is one of the largest rivers in southwest Ireland with a total catchment area covering approximately 2,000 square km. The catchment is defined by the land area drained by the River Lee, its tributaries and Cork Harbour. The catchment area of the River Lee, upstream of Waterworks Weir in Cork City, is approximately 1,150 square kilometres. The River Lee Catchment area is shown in Figure 1.

The study area is as shown in Figure 1 and covers from Inniscarra dam through predominantly greenfield areas west of the city through to the urbanised areas of Carrigrohane Road and Victoria Cross. From here it covers both the North and

South Channels and extends from Custom House Quay to Tivoli on the left bank and Páirc Uí Chaoimh on the right bank.

It includes the tributaries of the Bride (West), Shournagh, Curragheen, Glasheen, and Kiln in so far as flood levels on these watercourses are affected by the backwater effect from the design event on the Lee. However it excludes Bride (North), Glen and Glennamought. These are included in the Blackpool and/or Ballyvolane study area and therefore are not covered within this report.

A chainage system for the river system has been developed for this project and is used throughout this report, for reference purposes. Each channel has a two digit code 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, with the exception of the North and South Channel. This is to match the convention used in the CFRAMS Report to allow for ease of cross reference.

Figure 1: Lower Lee Study Area Map

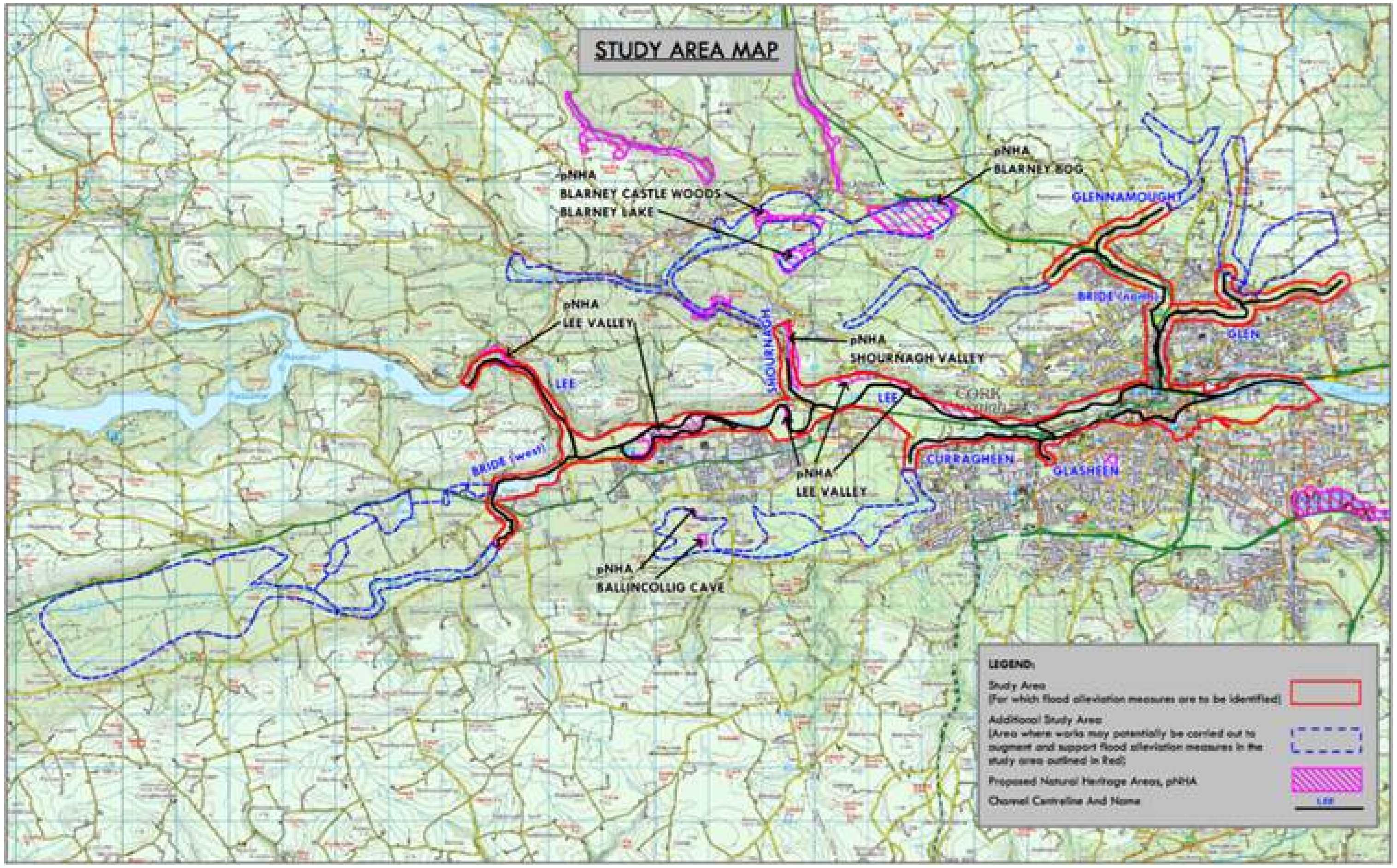
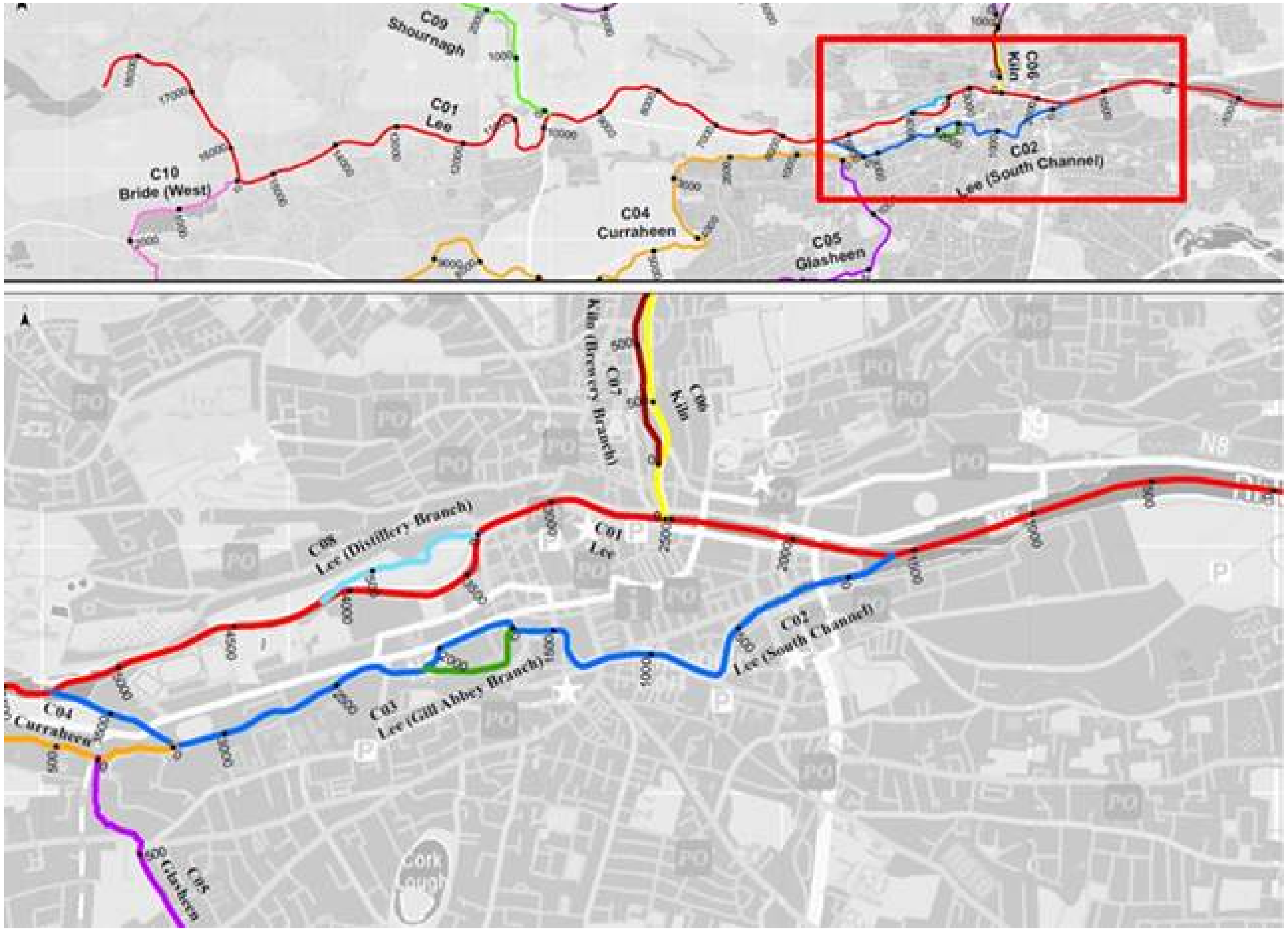


Figure 2: Lower Lee Channel Codes



1.4 Scope of Problem

A hydrological study and hydraulic modelling of the existing situation was carried out as part of this project. Significant data from the 2009 flood event was collated and analysed including the role of both reservoirs and the saturation of the catchment.

Significant data from the 2014 tidal flood event was also collated and used in calibrating the hydraulic modelling in the tidal reach.

The existing flood risk and flood mechanisms are described in detail in both the Lower Lee FRS Hydrology and Hydraulics reports.

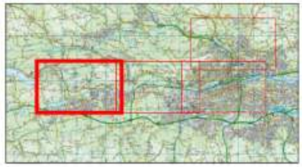
The predicted 1 in 100 year fluvial and 1 in 200 year tidal flood extent is shown in Figure 3 to Figure 5 overleaf.

Figure 3: Existing Flood Extent – Inniscarra/Ballincollig West

Legend

Existing 1% AEP Flood Extent

Key Plan



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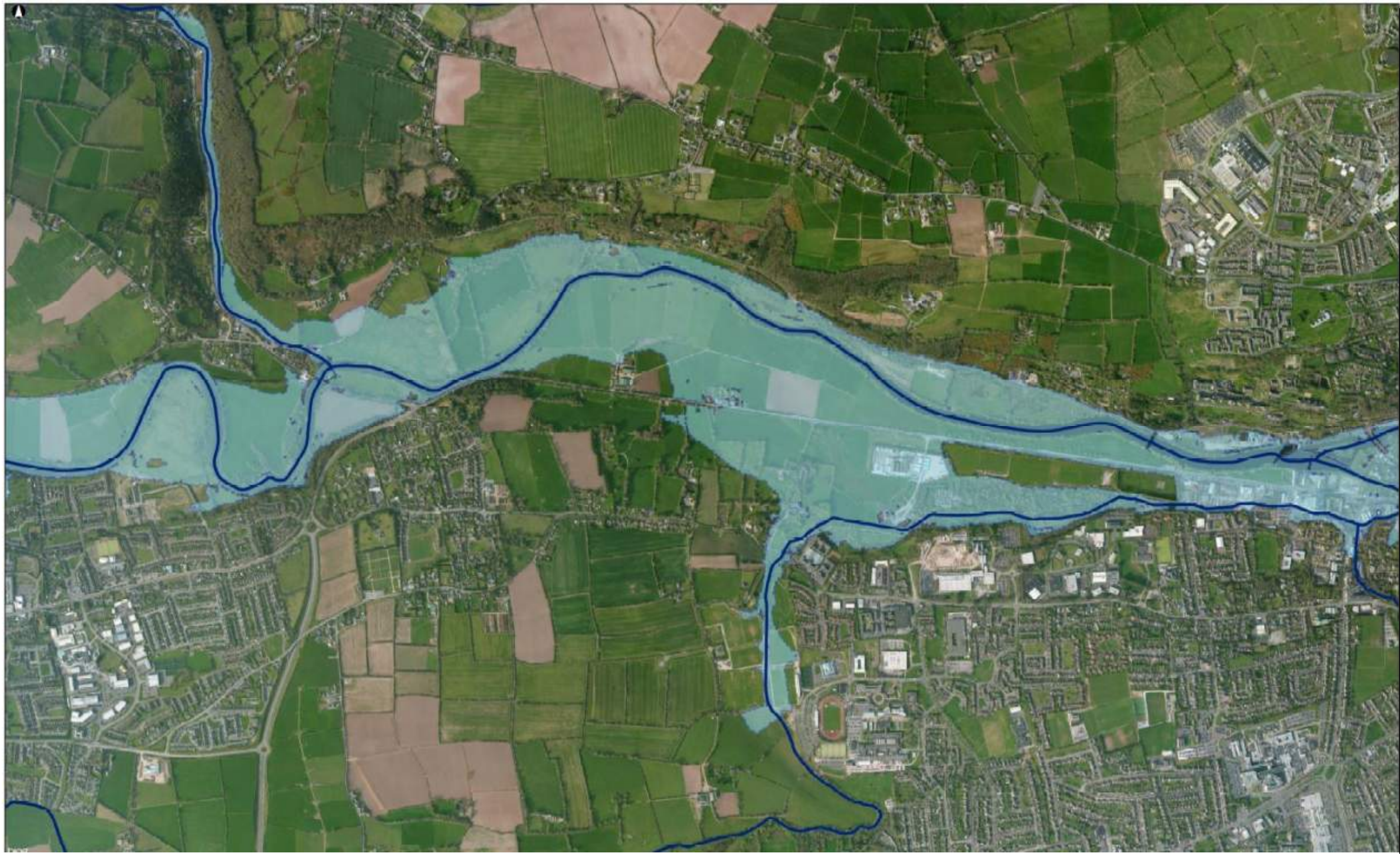
RYAN HANLEY

Figure 4: Existing Flood Extent – Ballincollig East/Carrigrohane Road



Legend

Existing 1% AEP Flood Extent

Key Plan

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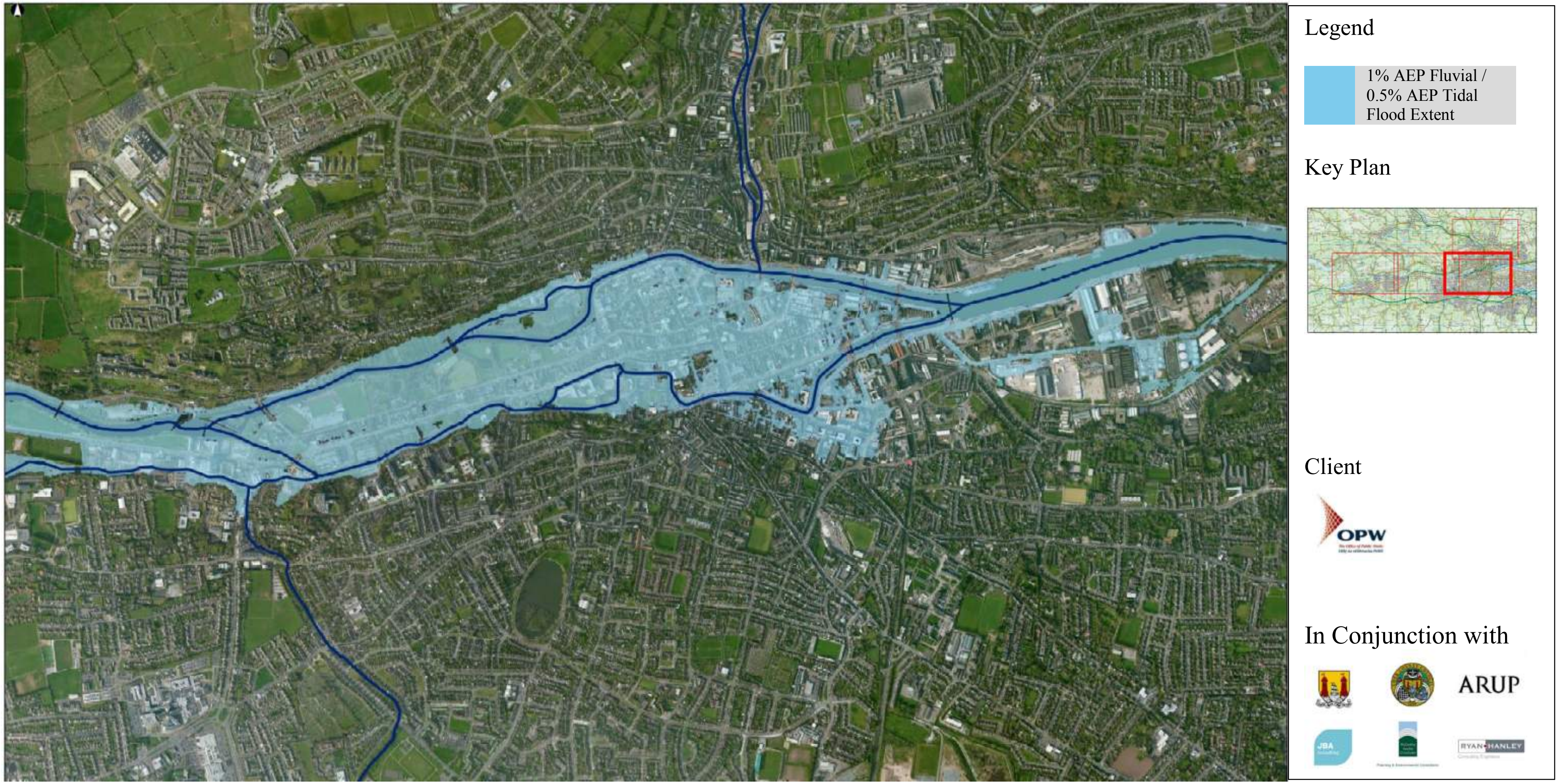
Figure 5: Existing Flood Extent – Cork City



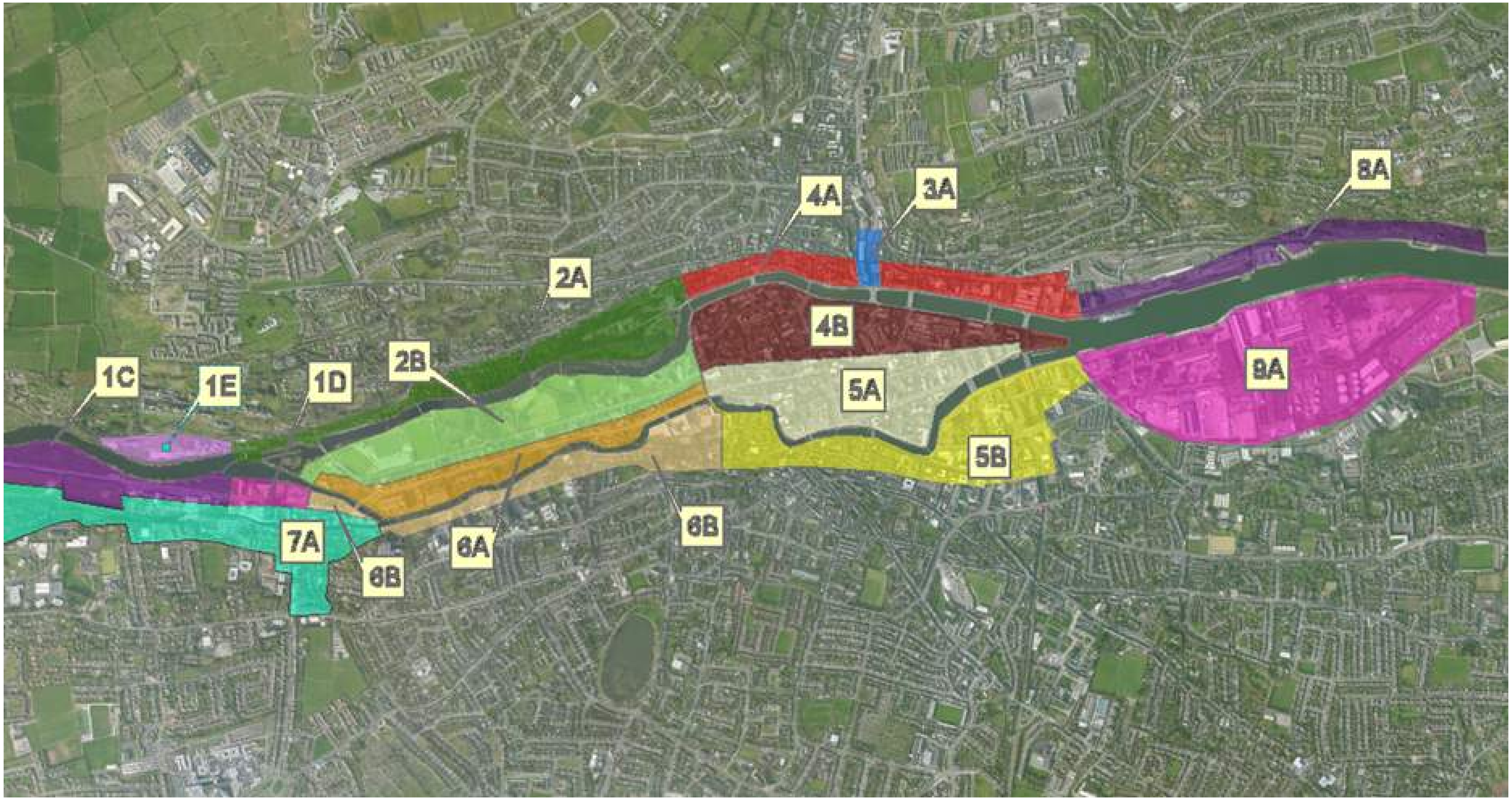
As this is an extensive scheme and the locations at risk are spread over a large area, it was considered appropriate to divide the assessment of the potential flood risk management measures into discrete areas as shown in Table 1 and Figure 6 and Figure 7 below.

Table 1: Areas for Assessment

Area No		Area Name	Extents
1	1A	Inniscarra	From Inniscarra Dam to Inniscarra Bridge
	1B	Ballincollig	Ballincollig to Leemount
	1C	Inchigaggin/Carrigrohane Road	Inchigaggin to Kingsley
	1D	Kingsley Area	Kingsley to South Channel Footbridge
	1E	Lee Road	Lee Road to Waterworks Weir
2	2A	NNC - North of North Channel West	Salmon Weir to St.Vincent's Bridge
	2B	CIW - South of North Channel West	Salmon Weir to Prospect Row
3	3	River Kiln	Brewery to St.Patrick's Bridge
4	4A	NNC - North of North Channel East	St.Vincent's Bridge to Penrose Quay
	4B	CIE - South of North Channel East	Prospect Row to Custom House Street
5	5A	CIE - North of South Channel East	Custom House Street to St.Finbarre's Bridge
	5B	SSC - South of South Channel East	Victoria Rd to St.Finbarre's Bridge
6	6A	CIW - North of South Channel West	St.Finbarre's Bridge to South Channel Footbridge
	6B	SSC - South of South Channel West	St.Finbarre's Bridge to South Channel Footbridge
7	7A	Curragheen River and Glasheen River	From South Channel to Model Farm Road
8	8A	North Docklands	Horgan’s Quay to opposite Páirc Uí Chaoimh
9	9A	South Docklands	Victoria Rd to Páirc Uí Chaoimh

Figure 6: Areas for Assessment West of the City

Figure 7: Areas for Assessment in City Centre



1.5 Scheme Objectives

The overarching objective of the project is to:

Develop a viable, cost effective and sustainable flood relief scheme for the study area (while building upon the findings of the Lee CFRAM Study).

This proposed solution will broadly follow the flood risk management measures recommended in the draft Catchment Flood Risk Management Plan, published in February 2010. The study is outlined in further detail in Section 2 below.

In summary, it sets out a range of potential flood risk management options for particular areas within the catchment including the Lower Lee (Cork City).

The Lee CFRMP recommended the following combination of measures as being the preferred flood relief solution for Cork City.

- Development of an appropriate flood forecasting system.
- Further optimisation of the operation of Inniscarra and Carrigadrohid reservoirs.
- Localised defences between Inniscarra and Cork City.
- Direct flood defences in Cork City.

The scheme is to be developed primarily to protect the affected areas against fluvial and tidal flooding. In addition, consideration will be given to the potential impact of any flood relief scheme on groundwater and pluvial flood risk.

2 Review of Lee CFRAM Study Outputs

2.1 Introduction

The Lee Catchment Flood Risk Assessment and Management Study (CFRAMS) identified locations within the River Lee catchment that are at significant economic, social and environmental flood risk and assessed a range of potential options to reduce these risks.

The starting point for the Lower Lee Flood Relief Scheme was a review and assessment of the findings of the Lee CFRAMS.

The Lee catchment was divided into a number of assessment units, at varying spatial scales. Analysis units (AU's) are large sub-catchments or areas of tidal influence. The study area lies within two AU's, the Lower Lee AU and Harbour / Tidal AU. These AU's are further broken down into areas of potential significant risk (APSR) which are existing urban areas with high degrees of flood risk. Cork City was identified as an APSR.

Flood risk management options were developed at both the AU and APSR scale firstly by undertaking a screening assessment of a range of possible flood mitigation measures, and then development of options to be assessed in greater detail.

2.2 Screening

The Lee CFRAMS identified a list of potential flood risk management options, both structural and non-structural, which were then considered for each AU and APSR. Through a screening process the applicability, technical and economic feasibility and social and environmental acceptability of each measure was assessed. Refer to Figure 8 for details of the measures assessed at the screening stage.

Figure 8: List of Measures Assessed at the Screening Stage (Reproduced from the Lee Catchment Flood Risk Assessment and Management Study Catchment Flood Risk Management Plan)

Long list of measures	
Baseline – Do nothing (assuming any current maintenance and management regime continues)	
Do minimum	
1	Reduce existing activities
2	Proactive maintenance
Non-structural / minor & localised modifications	
3	Develop a flood forecasting system
4	Targeted public awareness and education campaign
5	Individual property protection/flood proofing
Structural measures	
6	Rehabilitation, improvement of existing defences
7	Improvement in channel conveyance
8	Sediment management
9	Provision of permanent flood walls/embankments
10	Provision of demountable flood defences
11	Use of overland floodways (e.g. allowing flooding of roads in a controlled manner)
12	Flow diversion (full diversion / bypass channel, flood relief channel, etc.)
13	Flood storage reservoirs
14	Managed realignment
15	Tidal barrier

The following measures for the Cork City APSR were brought forward for a more detailed assessment in the option formulation stage of the Lee CFRAMS.

- Develop a flood forecasting system;
- Targeted public awareness and education campaign;
- Individual property protection / flood proofing;
- Rehabilitation, improvement of existing defences;
- Improvement in channel conveyance;
- Provision of permanent flood walls / embankments;

- Provision of demountable defences (requires flood forecasting to be robust);
- Flood storage reservoirs; and
- Tidal barriers (requires tidal flood forecasting to be robust).

The Catchment Flood Risk Management Plan (CFRMP) states that sediment management, use of overland floodways, flow diversion and managed realignment were not included in the option development stage as the physical conditions in the Lee catchment result in no practical opportunity to apply such measures.

2.3 Detailed Measures Assessment

The measures shortlisted for Cork City in the screening stage were then assessed to identify which measures or combination of measures should be taken forward for detailed assessment. Each option was then evaluated in relation to the 15 study objectives using a detailed multi-criteria analysis (MCA). The study objectives are reproduced from the CFRMP in Table 2 below.

Table 2: List of Objectives

Core Criteria	Objective
Technical	Ensure flood risk management options are operationally robust
	Minimise health and safety risk of flood management options
	Ensure flood risk managed effectively and sustainable into the future
Economic	Optimise economic return on flood risk management investment
	Minimise risk to infrastructure
	Manage risk to agricultural land
Social	Minimise risk to human health and life
	Minimise risk to community
	Minimise risk to, or enhance, social amenity
Environmental	Support the achievement of good ecological status / potential (GES/GEP) under the Water Framework Directive
	Minimise risk to sites with pollution potential
	Avoid damage to, and where possible enhance, the flora and fauna of the catchment

Core Criteria	Objective
	Avoid damage to, and where possible enhance, fisheries within the catchment
	Protect, and where possible enhance, landscape character and visual amenity within the catchment
	Avoid damage to or loss of cultural heritage importance, their setting and heritage value within the catchment

To determine the MCA score for each option, the objectives were weighted and the options were scored depending on how well it met each objective. The benefit-cost ratio (BCR) of each option was also assessed with a BCR of greater than one indicating that the economic benefit of the scheme outweighs the cost.

The options assessed for the Lower Lee AU, Harbour AU and Cork City APSR, the MCA scores and BCR are reproduced in Table 3. The options in bold were those taken forward to the Lee CFRMP.

Table 3: Options Assessed for the Lower Lee AU, Harbour AU and Cork City ASPR (Reproduced from the Lee CFRMP)

AU / APSR		Option Details		MCA Score	BCR
Lower Lee AU	Lower Lee AU	**Option 1**	**Further optimised operation of Carrigadrohid and Inniscarra Dams informed by integrated flood forecasting**	**1540**	**23.9**
		Option 2	**Develop a flood forecasting system combined with individual property protection and a targeted public awareness and education campaign**	**523**	**9.3**
	Cork City APSR	Option 1	Proactive maintenance of existing informal defences	-1385	0.6
		Option 2	Develop a flood forecasting system combined with a targeted public awareness and education campaign and individual property protection	501	8.9
		Option 3	Improvement in channel conveyance combined with	778	1.3

AU / APSR		Option Details		MCA Score	BCR
			provision of flood walls / embankments		
		Option 4	Provision of permanent flood walls / embankments	781	1.3
		Option 5	Provision of demountable defences combined with some permanent defences	613	2.3
Harbour AU	Harbour AU	Option 1	Proactive maintenance	-83850	0
		Option 2	**Develop a tidal forecasting system combined with a targeted public awareness and education campaign and individual property protection / flood-proofing**	**231**	**5.0**
		Option 3a	Tidal barrier at the mouth of Cork Harbour informed by a flood forecasting system	-71340	0.0
		Option 3b	Tidal barriers at Monkstown and Marloag Point informed by a flood forecasting system	-7515	0.2
	Cork City APSR	Option 1	Proactive maintenance	-20521	0.1
		Option 2	Develop a tidal forecasting system combined with a targeted public awareness and education campaign and individual property protection / flood-proofing	109	3.3
		Option 3	Provision of permanent flood walls / sea walls / revetments / embankments	-7308	0.2
		Option 4	Develop a tidal forecasting system combined with the provision of permanent flood walls / sea walls / revetments / embankments and demountable flood defences	-2621	0.4

AU / APSR		Option Details		MCA Score	BCR
		Option 5	Tidal barrier near Jack Lynch Tunnel	Hydraulic computer modelling indicates that this option was not technically feasible as the low storage volume available upstream of the barrier resulted in significantly worsened fluvial flooding in Cork City as a result of impounding the river.	
Combined fluvial and tidal	Cork City APSR	**Option 1**	**Combined tidal and fluvial forecasting system with a targeted public awareness and education campaign and individual property protection / flood-proofing**	**436**	**8.2**
		Option 2	**Provision of permanent flood walls / sea walls / revetments / embankments to protect against both tidal and fluvial flooding**	**774**	**1.2**
		Option 3	Develop a combined tidal and fluvial forecasting system with provision of permanent and demountable defences to protect against both tidal and fluvial flooding	624	2.5

In general, only options with a positive MCA score were included in the development of the CFRMP. One exception to this approach is the tidal defences in Cork City which were further analysed as combined fluvial / tidal options.

The option of providing a tidal barrier at a number of locations in Cork Harbour was also assessed as part of the Lee CFRAMS. The CFRMP found that this option was not viable for the current scenario.

2.4 Components of the Lee CFRMP

2.4.1 Lower Lee AU

The following options were included in the Lee CFRMP at the AU level:

- Fluvial and tidal forecasting systems for widespread coverage, including the Cork City APSR; and
- Revised operating rules for Carrigadrohid and Inniscarra dams, informed by flood forecasting and facilitated by increased safe discharge levels, to optimise the flood risk management potential in the Lower Lee AU including Cork City APSR.

As tidal defences for Cork City were not deemed to be viable in isolation but are potentially viable in conjunction with fluvial defences, the combined option was taken forward for detailed assessment.

2.4.2 Cork City APSR

The Lee CFRMP summarises the preferred approach to the provision of defences in Cork City. The report recognises that the development of these measures is complicated by the potential modification to the Carrigadrohid and Inniscarra dams operating regulations. The report states that further assessment of the effectiveness of changing these regulations is required to establish its potential but notes that fluvial defences may still be required along sections of the River Lee and Curragheen River. The Lee CFRAMS noted that potential changes to the dam operations does not address the risk of tidal flooding in Cork City.

The preferred option for flood defences in Cork City is identified as permanent flood walls and/or embankments to manage both tidal and fluvial risk. It recommends that these defences are implemented in conjunction with the flood forecasting system and revised dam operating rules identified for the Lower Lee AU.

3 Stakeholder Input and Consultation

3.1 Constraints Study

A Constraints Study Report was prepared as part of this project by the Environmental Team of Ryan Hanley and McCarthy Keville O' Sullivan. It was a combined Constraints Report for the Lower Lee (Cork City) Drainage Scheme and the River Bride (Blackpool) Certified Drainage Scheme as it preceded the separation of both elements into discrete 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 above report have been taken into account in the development of the all options and selection of the preferred option.

3.2 Public Consultation

An important element of the Lower Lee FRS is consultation with all interested parties including the public. This is carried out at strategic stages in the study, including the identification of preferred options.

This gives interested parties the opportunity to communicate local knowledge and how they are currently affected, and to give their views on the preferred options, thereby influencing the decision-making process.

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

Throughout the design to date, the design team have worked closely with all key stakeholders ensuring consultation and communications to bring local residents and stakeholders closer to the decision making process, allowing for an open, accountable and robust approach.

Balancing all constraints, the OPW and its design team endeavoured to find the most prudent solutions behind which stakeholders can form a consensus, while maintaining quality, efficiency, cost effectiveness and deliverability of the project.

3.3 Public Consultations Days

Two separate Public Information Days (PIDs) were held during the course of Phase 1 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 for the Lower Lee FRS.

The Public Information Day did not have as large an attendance as might have been expected in advance, despite an extensive publicity campaign.

Nevertheless, a sizable amount of valuable information and comment was obtained both on the day of the PID and received subsequently.

Overall feedback from members of the public was that they were happy to have been involved in the Public Consultation; but wanted the process to proceed as quickly as possible to bring forward the date when flood relief measures would be implemented on the ground.

A number of comments were made about the need for ongoing maintenance. Many comments also referenced the need to maintain good water quality, and the resultant benefits of doing so for fisheries and associated tourism and leisure activities. The majority of other comments received were one-off statements, and did not appear in more than one questionnaire/submission.

A summary of the submissions received from the public is included in the Lower Lee Constraints Study Report.

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.

A summary of the comments was documented and submitted to OPW. The feedback received from both PIDs was taken on board and helped to inform the development of the preferred option.

Throughout the consultation process, a number of alternative solutions were proposed by members of the public. These were considered during the scheme design stage and are outlined in Appendix A.

3.4 Consultation with Key Stakeholders

A key tool in ensuring stakeholders' views can be incorporated where necessary has been arranging and facilitating multiple stakeholder workshops at appropriate times throughout the project. These balanced with timely on-the-ground meetings and site visits has allowed for public and stakeholder concerns to be identified and addressed at source whilst creating the opportunity for interactive discussion with key stakeholders.

Meetings have been held between the Design Team, Cork City Council, Cork Chamber of Commerce, Cork Business Association, other stakeholders, landowners and other interested parties as required during the design process.

These meetings have facilitated an open dialogue on the developing options and allowed useful local knowledge to be included in the scheme development and assessment.

The design team recognised the crucial importance of ensuring a sensitive approach to the designs with an understanding of what can be committed to and what cannot – balancing stakeholder requirements with project technical and economic constraints. The design team has also sought to build strong connections and maintain open communications between the key stakeholders and the Steering Group – understanding that the success of this will be influential in the overall success of the project. It is recognised that, since the project will be developed over a number of years through several phases and stages (from the early site investigation/topographic surveys through to the construction and ongoing maintenance of the scheme), strong relationships between all parties is vital toward ensuring the best value and outcome is achieved from the project.

Key stakeholders (for example Cork Business Association, Cork Chamber of Commerce, Port of Cork and others) were engaged at the earliest stages and liaised with regularly through the project as the proposals evolved. This consultation was considered critical to ensuring the project objectives addressed the crucial City's needs and requirements. Port of Cork and Transport Infrastructure Ireland (TII) were engaged with to ensure solutions at the Port and on NRA bridges and routes met their requirements.

3.4.1 Steering Group

The overall governance of the project has been driven by the Steering Group comprising the key decision makers and stakeholder representatives.

The key Steering Group members include the following organisations:

- Office of Public Works (the client),
- Cork City Council,
- Cork County Council,
- ESB,
- The Engineering Team of Arup in association with JBA Consulting.
- The Environmental Team of Ryan Hanley and McCarthy Keville O'Sullivan.

The Steering Group has coordinated closely and met on a regular (generally monthly) basis throughout all of the key project phases since the inception of the project. This regular coordination has led to greater collaboration and efficiency in the decision making process through the project.

Cork City Council was fundamental to the decision making process for crucial aspects of the project such as finishes, alignments, compatibility with public realm improvements and general approaches to the solutions. The two key areas of focus were the city centre quays and the amenity areas of Lee Fields and Fitzgerald Park.

In terms of the city quays, the City Architect and Heritage/Planning departments liaised closely with the design team to agree preferred railing and finish details for each area, taking into account the particular setting, heritage and amenity value of each area. This ensures that the flood defence element are integrated in a holistic way into the setting and add value to the city.

Multiple detailed workshops were held between Cork City Council and the Steering Group to agree preferred approaches – for example the required finishes on each quay, road re-grading and other critical decisions that affect the look and feel of the city centre.

In terms of the Lee Fields and Fitzgerald's Park, the City Council engaged the services of a specialist landscape consultant in order to help shape the preferred design solutions through the western areas. It was recognised that these areas form some of the most sensitive and important areas of the city and it was critical to arrive at the correct solution. The design team liaised with the City Council and its landscape architect to incorporate significant aspects of the overall long terms landscape and amenity strategy as part of the proposed scheme.

3.4.2 Statutory Consultees

Liaison has taken place with a large number of statutory consultees in relation to this flood relief scheme. Please refer to the Environmental Impact Statement for further details.

An EIA scoping report, providing details of the works footprint and emerging preferred flood relief option, was prepared by McCarthy Keville O'Sullivan Ltd. in association with Ryan Hanley and circulated on 2 November 2016.

Comments were requested from the relevant personnel/bodies in their respective capacities as consultees with regards to the EIA process.

The following is a list of the consultees who were issued with a copy of the scoping report:

- Gas Networks Ireland
- Inland Fisheries Ireland
- Transport Infrastructure Ireland (TII)
- Cork County Council (County Manager)
- Fáilte Ireland
- Office of Public Works
- Waterways Ireland
- Coillte Teoranta
- ESB
- Department of Communications, Energy and Natural Resources
- Development Applications Unit of Department of Environment, Community and Local Government

- National Monuments Service, Department of Arts, Heritage, Regional, Rural & the Gaeltacht
- Department of Environment, Community and Local Government
- An Comhairle Ealaion (The Arts Council)
- Department of Agriculture, Food and the Marine
- Department of Jobs, Enterprise and Innovation
- Environmental Protection Agency (EPA)
- Forest Service (Department of Agriculture, Fisheries and the Marine)
- Geological Survey of Ireland
- Health and Safety Authority
- HSE Southern Regional Health Forum
- National Monuments Service
- National Museum of Ireland
- South West Regional Authority
- Southern River Basin District Office
- The Heritage Council
- Eircom
- Irish Water
- Environment Section - Cork City Council
- Planning Section - Cork City Council
- Water Services Section - Cork City Council
- Divisional Manager, Cork County Council
- Director of Services, Cork County Council
- County Engineer, Cork County Council
- Communications Officer, Cork County Council
- Archaeology Section, Heritage Unit, Cork County Council
- An Taisce - The National Trust for Ireland
- Bat Conservation Ireland
- Birdwatch Ireland
- Irish Farmers Association (Cork Region)
- Cork Business Association
- Cork Chamber of Commerce
- Cork Historical and Archaeological Society
- Port of Cork

For full details of all of the statutory consultation, please refer to the Environmental Impact Statement.

3.4.3 Landowner Consultation

The design team appreciated the fundamental importance of early engagement with the affected landowners on the scheme and therefore placed a significant emphasis on this element.

An extensive landownership search was carried out on behalf of OPW to identify all landowners affected by the scheme, including farmers, private landowners and commercial businesses. A significant public consultation process was subsequently carried out, including letter drops and door knocking.

The vast majority of the key affected landowners were contacted and engaged with to explain the proposed work. In many cases landowners were also met on site to ensure the design team were able to fully understand the landowners' unique concerns, preferences and suggestions and crucially the site specific complexities for each area. Equally these meetings sought to ensure the affected landowners were fully informed and understood the proposed works (including the nature of and rational for the works, the defence alignments and finishes, access requirements and construction issues) and the processes by which they may raise additional queries or comments.

Arup addressed any landowner queries and endeavoured to understand the land use and constraints of the affected areas to inform the scheme design. All landowner feedback (including exhibition submissions) will be further considered and incorporated as the design moves into detailed design stage.

A large consultation database was built up capturing all of the landowner interactions, requests and agreements. This will be maintained going forward into detailed design to ensure all issues are tracked and addressed.

Landowner interactions and requests were discussed regularly at the steering meetings and design team meetings to determine what suggestions and feedback could be adopted or addressed.

4 Initial Screening of Potential Measures

4.1 Introduction

This section details all the flood risk management measures considered during the screening stage of the project, following on from the work undertaken in the Lee Catchment Flood Risk Assessment and Management Study (CFRAMS). These measures have been subjected to a preliminary assessment with regard to their viability in terms of the following criteria:

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

The flood risk management measures which have been assessed, as part of this initial screening process are contained in Table 4 below.

Table 4: Screening of Flood Risk Management Measures

Possible Flood Risk Management Measure		Applicability	Economic	Environmental	Social	Cultural	Screening Result	Comment
Base-line	Do Nothing	Y	N	Y	N	Y	Not Viable	This option assumes no further work or expenditure on measures to reduce flood risk in the study area. The Do Nothing scenario is defined as the option involving no future flood defence expenditure. The implication is that the existing risk of flooding persists or possibly worsens in the study area. This is not considered to be a viable standalone option as it fails to meet the needs of the residents and business owners.
Base-line	Do Minimum	Y	Y	Y	Y	Y	Not Viable	This option provides the baseline for the study and would consist of minor works and maintenance measures, which could include filling in gaps in existing masonry river walls etc. The risk of flooding would remain high. Therefore, this is not considered to be a viable measure as it fails to meet the needs of the residents and business owners. Using this as the baseline scenario, however, allows the benefits of all existing measures to reduce the flood risk to be identified. It places the benefit of these measures into true perspective.
Non- Structural Measures	Modified Operation of Inniscarra and Carrigadrohid Dams	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment
Non- Structural Measures	Flood Forecasting and Flood Early Warning System	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment
Non- Structural Measures	Planning Control	Y	Y	Y	Y	Y	Not viable as a Standalone measure. May be viable as an ancillary measure.	This measure would assist in ensuring flood risk is not increased by future development. The measure would take a long time to implement, and would not reduce the current flood risk to an acceptable level. Therefore, it is not considered viable as a standalone measure. It may still be appropriate to implement along with other measures.

Possible Flood Risk Management Measure		Applicability	Economic	Environmental	Social	Cultural	Screening Result	Comment
	Building Regulations	N					Not Viable	Long time to implement, and would not reduce the flood risk to an acceptable level. Will however form part of the long term strategy to minimise the potential impacts of climate change.
	Public Awareness Campaign	Y	Y	Y	Y	Y	Not viable as a standalone measure. May be viable as an ancillary measure.	This measure would help to increase public awareness and preparedness for future flood events. However, the measure would not reduce the current flood risk to an acceptable level. Therefore, it is considered unviable as a standalone measure. It may still be appropriate to implement along with other measures.
	Land Use Management	N					Not Viable	Long time to implement, and would not reduce the flood risk to an acceptable level.
Structural Measures	Creation of Washlands	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment.
	Direct Flood Defences	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment
	Channel Widening	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment
	Sediment/Debris Control	N						The existing reservoirs remove much of the sediment from the system meaning sedimentation is not a significant issue downstream of Inniscarra Dam. Debris blockage risk is low due to the scale of the river and flows and thus large bridge structures.
	In-channel Flow Regulation	Y	Y	Y	Y	Y	Potentially Viable	This would focus on flow regulation and flow spilt between the North and South Channel of the Lee. Undertake Technical Assessment
	Bridge/Weir Modifications	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment
	Local Conveyance Improvements	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment.
	Diversion Channels or Culverts	N					Not Viable	The Lower Lee valley through Cork is heavily urbanised and does not contain any potentially viable diversion routes.
	Upstream Flood Storage	Y	Y	Y	Y	Y	Potentially Viable	Undertake Technical Assessment.

Possible Flood Risk Management Measure		Applicability	Economic	Environmental	Social	Cultural	Screening Result	Comment
	Property Occupier Relocation	N					Not Viable	This measure involves the relocation of people and businesses from properties at risk of flooding to an area with lower flood risk. It is not considered feasible, due to the urbanised nature of the area at risk and the large number of properties at risk.
	Individual Property Protection	N					Not Viable	Not considered feasible due to the large no. of properties located in the Cork City area
	Pumping	Y	Y	Y	Y	Y	Potentially Viable	Localised pumping of surface water will form part of any scheme.
	Tidal Barrage	N					Not Viable	Assessed in detail in Lee CFRAM Study and found to be prohibitively high cost and significant environmental impacts.

4.2 Non-Viable Measures

4.2.1 Introduction

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

- Do Nothing
- Do Minimum
- Non-structural Measures
    - Planning Control
    - Building Regulations
    - Public Awareness Campaign
    - Land Use Management
- Structural Measures
    - Property Occupier Relocation
    - Individual Property Protection
    - Pumping
    - Tidal Barrage

4.2.2 'Do Nothing' Measure

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 and possibly worsens over time. This is not considered to be a sustainable option and has therefore been ruled out at the initial screening stage.

4.2.3 Non-structural Measures

Planning Control and Land Use Management

Planning Control, Land Use Management and revisions to Building Regulations would assist in ensuring flood risk is not increased by future development. Proposed developments 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 would increase the speed of runoff, giving rise to earlier and higher flood peaks. Planning control would take a long time to implement and would not reduce the current flood risk to an acceptable level. It is therefore considered unviable as a standalone measure. It may still be appropriate to implement in conjunction with other measures.

Public Awareness

A Public Awareness Campaign would help to increase public awareness and preparedness for future flood events. However, the measure would not reduce the current flood risk to an acceptable level. It is therefore not considered viable as a standalone measure. It may still be appropriate to implement this measure in conjunction with other measures and it will be considered as such.

4.2.4 Structural Measures

4.2.4.1 Relocation

Relocation would involve 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 from Inniscarra Dam to Cork City, property relocation has been ruled out at the initial screening stage.

4.2.4.2 Individual Property Protection

This measure would protect properties on an individual basis. This typically consists of demountable barriers, which are effective 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 as standalone measure due to the large number of properties at risk and the large predicted flood depths. Therefore this measure has been ruled out at the initial screening stage.

4.2.4.3 Pumping

This measure would involve pumping excess flood flow away from the main channel in order to allow water to remain in-bank. This measure would involve construction of a water offtake structure and pumping chamber upstream of the area at risk, and a rising main/gravity main to the discharge point. When the water level in the river rises above a certain threshold, water spills into the wet well of the pumping station and is pumped downstream in parallel to the main channel. At a suitable point downstream of the area at risk, the pumped flow re-joins the main river. Due to the large flow volume, this measure would have prohibitively high capital and maintenance costs. In addition, there are significant negative environmental and social impacts and it is clear that pumping is not a viable option.

4.2.4.4 Tidal Barrage

A tidal barrage to protect Cork City from tidal flooding would involve providing a tidal barrier downstream of Cork City. One potential location would be immediately upstream of the Jack Lynch Tunnel as illustrated in Figure 9.

Figure 9: Tidal Barrage at Jack Lynch Tunnel

The tidal barrage would have an approximate length of 375m.

This option was considered as part of the Lee CFRAMS which concluded that it was not technically viable.

Preliminary assessments undertaken as part of the Lower Lee FRS confirmed that this option is unlikely to be technically viable as there would likely be insufficient storage volume behind the barrier to store fluvial flows impounded by the barrier during the time the barrier would be closed.

An alternative location for a tidal barrage would be in the lower harbour to the west and east of Great Island. The barriers would potentially be located between Monkstown/Rushbrook and Marlogue/East Ferry as shown in Figure 9.

Figure 10: Tidal Barrage (a) Monkstown/Rushbrook / (b) Marlogue/East Ferry

The Lee CFRAMS concluded that whilst a barrage either side of Great Island would likely be technically viable, it was not economically viable in the current scenario and would also likely have significant environmental impacts.

The Lee CFRAMS estimated a baseline construction cost estimate for the barrage in excess of €340m. When allowing for operation and maintenance as well as other project costs, this would equate to a Net Present Value for this option well in excess of €500m. A separate high level study commissioned by OPW suggested that a cost of €900m was more likely.

Circa 320 lin.m of 23m high barriers would be required at Monkstown with 340m of 13m high barriers required at East Ferry. It is worth noting that Cork Harbour is particularly deep. To put this in context, the Thames Barrier is 520m in width (less than the total length required here) and its gates have a total height of 20m (less than what would be required at Monkstown). The construction cost of the Thames Barrier is in the order of STG£1.6bn at 2016 prices.

It is clearly that any of the above estimates mean that a tidal barrage is not a viable option at present.

It is further worth noting that the cost of tidal barrages has historically often been significantly underestimated at scheme stage.

For the above reasons, this measure has been ruled out at the initial screening stage.

4.3 Potentially Viable Measures

Following the screening exercise, a number of flood risk management measures were identified as viable measures and are taken forward for technical assessment.

The following summarise these measures:

- Do Minimum
- Non-Structural Measures
  - Maximising potential benefit via modified operation procedures of Inniscarra and Carrigadrohid Dams for extreme flood events; and
  - Flood Forecasting and Early Warning System.
- Structural Measures
  - Upstream Washlands
  - Upstream Flood Storage
  - Direct flood defences
  - In-channel flow regulation
  - Local conveyance improvements
  - Channel widening
  - Bridge/Weir modifications
  - Localised surface water pumps

The details of the non-structural and structural measures are presented in Sections 5 to 10 hereafter.

5 Assessment of Potentially Viable Measures

The potentially viable flood risk management measures are assessed under the following headings:

- Do Minimum
- Non-Structural measures
  - Optimised Dam Operating Procedures is addressed in Section 6
  - Flood Forecasting and Early Warning System is addressed in Section 7
- Designation of Washland Areas is addressed in Section 8
- Upstream Flood Storage is addressed in Section 9
- Structural measures are addressed in Section 10

The non-structural measures are not specific to a geographical location as they would be implemented for the whole scheme. These are described in detail below.

For the detailed assessment of the potentially viable structural measures, the study area and viable measures have been divided into logical geographical areas, as outlined in Table 1. These are described in detail in Section 10.

All measures are detailed sufficiently to allow the development of flood relief options, which may be a combination of a number of measures.

5.1 'Do Minimum' Measure

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 river system from Inniscarra Dam to Cork City.

Maintaining existing channels and culverts free of debris, clearing channels of vegetation and keeping gullies clear are typical of the do minimum approach.

This measure has been taken forward primarily for the purpose of using it as the baseline scenario for the scheme. It will allow a proper comparison between the existing situation and the benefits of viable options.

6 Revised Dam Operating Procedures

6.1 Purpose

New flood operational procedures have been developed for Carrigadrohid and Inniscarra dams, which will be implemented during periods where extreme fluvial flood events are forecasted and which require intervention to safely manage flood risk downstream of Inniscarra and through Cork city.

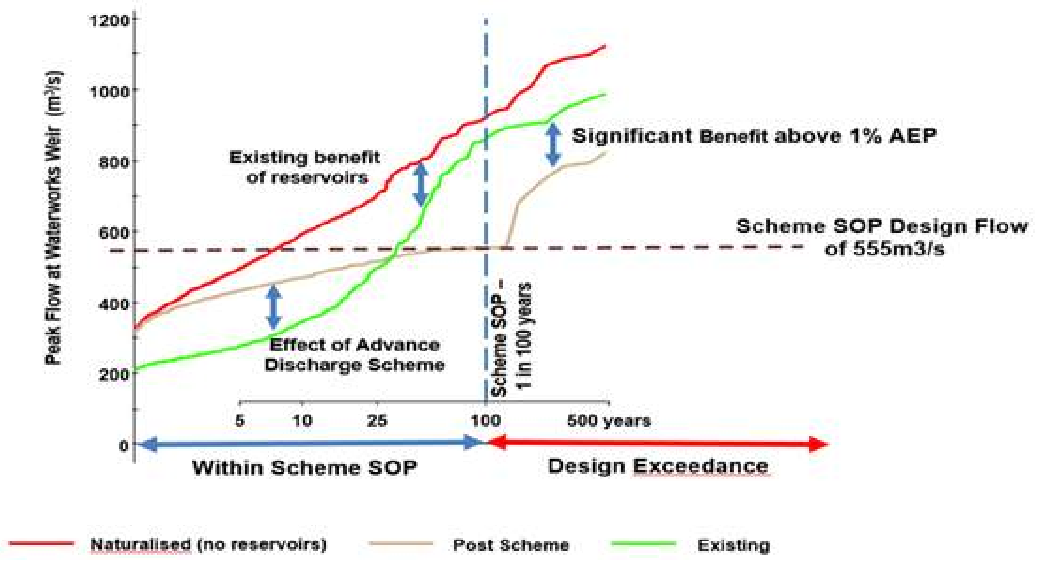
The primary purpose of the new rules is to create storage in the reservoirs in advance of a flood that might otherwise exceed the design flow in Cork. This storage will then allow the design flood through Cork to be managed by modifying dam discharges in consideration of inflows on the downstream tributaries (and the tide) so that the total peak flow in Cork is limited to less than the 1% Annual Exceedence Probability (AEP) (1 in 100 year) fluvial design flow of 555m^3/s at Waterworks Weir. The new rules will also include measures for management of discharges during high tides in Cork City.

The new procedures will involve increased advance discharges to create storage. This has the effect of increasing the frequency of medium flood events, which will result in earlier and more frequent flooding (in medium flood events) of primarily agricultural lands downstream in areas termed as 'Washlands'.

'Washlands' are those areas adjacent to the river (and part of the Lee floodplain) which, under the Scheme, will be deliberately flooded in advance of a forecasted extreme event, to facilitate pre-emptive lowering of water levels in Carrigadrohid and Inniscarra reservoirs, to create additional storage/attenuation capacity, and subsequently reduce the peak flow during the event.

The change in flood frequency can be seen in Figure 11 below, which demonstrates the change in flood frequency, i.e. a reduction in the design flow for the 100 year or 1% AEP event and an increase in flow for the more frequent events.

Figure 11: Change in Flood Frequency



6.2 Constraints

The following key constraints were observed in the development of revised dam operating procedures:

- The normal range of operating levels in the dams is not altered (i.e. outside of 'flood protocol' times, ESB will continue to operate as normal).
- Minimum and maximum reservoir levels and/or seasonal variations have not been altered to avoid impacting existing environmental receptors/constraints.
- Dam safety rules are not impacted, i.e. once levels in the reservoirs exceed ESB's safety thresholds, dam safety takes precedence and greater discharges will occur. In this scenario, emergency procedures will be put in place and warnings will be issued to advise of flooding as a result of a design exceedence event.
- For road embankment safety reasons, discharges from Carrigadrohid are constrained by a maximum drawdown rate.
- Inniscarra discharges are physically constrained by available head at top sluices.
- For the safety of downstream river users, there is a limitation on the rate of change of reservoir discharges.

6.3 Operation

The following summarises the proposed operation of the dams at various times:

Normal Time	Most of the time, the dams will continue to operate as at present.
In advance of Predicted Extreme Event	The new procedures will involve increased advance discharges (with graduated increases) to create storage in advance of the flood.
During Fluvial Event	During the rising flood, continued increased discharges, not exceeding the threshold of flooding, will ensure that dam storage is retained until it is needed at the peak of the event.
During Tidal Event	The New Rules will allow dam discharges to be managed optimally in conjunction with the tidal cycle, and inflows on downstream tributaries.

6.4 When Flood Conditions come into Force

Based on historical analysis, only inflows to Carrigadrohid of greater than 400m^3/s have the potential to give rise to peak flows in Cork in excess of the 1% AEP design flow of 555m^3/s. Therefore intervention is only required in scenarios where peak inflows to Carrigadrohid are likely to exceed 400m^3/s.

Because it can take up to 4 days in advance to safely draw down the reservoirs to the required level, actions must be taken based on predictions of peak flow generated from forecasted rainfall.

Continuous monitoring and simulation of predicted rainfall using the new flood forecasting system (FFS) will allow potentially significant flood events to be detected further in advance.

When a potentially significant event is detected by the forecasting system, the ‘flood protocol’ would be triggered.

Flow into Carrigadrohid is predicted by the FFS from a hierarchy of rainfall sources. Every forecast uses:

- Observed data where it is available.
- Met Eireann’s Harmonie data for the first 4 hours into the future.
- The European Centre for Medium Range Forecasts’ (ECMWF) deterministic forecast from 4 to 120 hours beyond that.

However, at 4 days out, there is significant uncertainty in relation to forecasted rainfall. There is also a historic under predictive bias in forecasts. Therefore lower trigger levels need to be set to ensure that potentially significant events are not missed, with lower trigger levels at longer lead times (i.e. where uncertainty is greatest). Adopting these conservative triggers will mean that there will be some false alarms.

By comparing recorded inflows against the available historic forecast data over a period of the last 10 winter years (2007 to date), the following threshold/trigger levels have been established and adopted.

- Predicted inflow to Carrigadrohid of greater than 180m^3/s at a lead time of between 96 and 48 hours; (Triggers Flood State D – see section 6.5.1).
- Predicted inflow to Carrigadrohid of greater than 285m^3/s at a lead time of less than 48 hours (triggers Flood State C or B – see sections 6.5.2 and 6.5.3).

An alarm is raised by the FFS if the forecast inflow to Carrigadrohid exceeds either threshold at the respective time. The timing of the threshold crossing is noted by the Flood (Advisory) Body.

Drawdown regimes are then implemented based on the output from the FFS for the coming period, confirmed by the Flood (Advisory) Body and enacted by the Reservoir Operator.

The flood control procedures (or drawdown regime applicable) fall into a number of categories, called Flood States, all related to when the threshold is forecast to be crossed. These 'flood states' are described in the section below.

6.5 Flood States, Actions and Frequencies

6.5.1 Flood State D

Flood State D is invoked if the Carrigadrohid inflows are forecast to exceed $180m^3/s$ within the following 48 to 96 hours.

Flood State D is only cleared if the forecast flow drops 10% below $180m^3/s$. This is to avoid operations flicking between States for different forecasts.

Flood State D triggers the first response to a flood at the longest lead time. Uncertainty is therefore considerable. Reservoir operation aims to lower water levels to Flood Risk Level (FRL) by the time the 48 lead time point is reached.

Carrigadrohid discharges are constrained by the drawdown rate limits and by levels in Inniscarra.

Using observed reservoir levels and simulated inflows, the FFS calculates the average discharge rate required to achieve FRL 48 hours before the predicted crossing.

Discharges from Inniscarra should not exceed $150m^3/s$ in this period. However, this constraint may be relaxed to $200m^3/s$ in certain exceptional circumstances.

As the proposed discharge rate during Flood State D is the same as ESB's current maximum advance discharge rate, the extent of inundation of downstream washlands will not differ significantly from the current pre-flood regime. In terms of frequency of such discharges, we do not envisage a significant increase in the occurrences of such discharges.

6.5.2 Flood State C

Flood State C is invoked if the Carrigadrohid inflows are forecast to exceed $285m^3/s$ within the following 24 to 48 hours.

Flood State C is only cleared if the forecast flow drops 10% below $285m^3/s$. This is to avoid operations flicking between states for different forecasts.

Between 48 hours and 24 hours, discharges of $200m^3/s$ are prescribed for Inniscarra where hydraulic head allows. In extreme circumstances, it is permissible to discharge $300m^3/s$ in this period. Such action is only likely when two large events are occurring together, but the first one is not large enough to be regulated in its own right. Discharges from Carrigadrohid are restricted to $300m^3/s$ if Inniscarra levels are below 49mOD and to $150m^3/s$ above 49mOD (and an interpolated rate in between).

Maximum drawdown rate restriction applies at Carrigadrohid.

Flood State C will occur less frequently than Flood State D, as the trigger level in terms of forecasted inflow to Carrigadrohid has increased and there will be less uncertainty in forecasts at the shorter lead time.

With discharges generally of 200m^3/s, and occasionally at up to 300m^3/s, Flood State C represents a significant change from the existing regime as ESB's current operating rules don't include for discharges of this magnitude unless the inflow is higher, as it could result in flooding of downstream buildings. After completion of the scheme, these larger discharges will become possible however as direct defences (walls and embankments) will protect against flooding of downstream properties.

6.5.3 Flood State B

Flood State B is invoked if the Carrigadrohid inflows are forecast to exceed 285m^3/s within the next 24 hours.

Flood State B is only cleared if the forecast flow drops below 260m^3/s. This is to avoid operations flicking between states for different forecasts.

In Flood State B, the aim is to discharge 300m^3/s from Inniscarra (although this will often only be achieved for a short period due to hydraulic head limitations). Maximum drawdown rate restriction applies at Carrigadrohid. There is no restriction on the rate of drawdown for Inniscarra. In the last 24 hours before an event, the discharge restriction on Carrigadrohid is 300m^3/s regardless of Inniscarra levels.

Flood State B will occur less frequently than Flood State C, as there will be less uncertainty in forecasts at the shorter lead time.

With discharges of up to 300m^3/s, Flood State C also represents a significant change from the existing regime as ESB's current operating rules don't include for discharges of this magnitude unless the inflow is higher, as it could result in flooding of downstream buildings. After completion of the scheme, these larger discharges will become possible however as direct defences (walls and embankments) will protect against flooding of downstream properties.

6.5.4 Flood State A

Flood State A is invoked when the 400m^3/s threshold inflow to Carrigadrohid is exceeded (or forecast to be exceeded at a short lead time of 3 hours).

Flow forecasts into Carrigadrohid at a short lead time (3 hours or less) are based on observed, not forecast rainfall. Error correction will also constrain uncertainty at this point. The 'true' threshold of 400m^3/s can therefore only be evaluated at that lead time. Note that the maximum flow in Cork will occur much more than 3 hours after this point. For reference, in November 2009, 11 hours elapsed between 400m^3/s being exceeded on the inflows to Carrigadrohid and 555m^3/s being exceeded in the City. With 3 additional hours lead time and greater use of storage, that figure is likely to be 15 - 18 hours.

At 3 hours lead time, uncertainty in forecast inflows is close to a minimum, allowing possible impacts in Cork to be considered with more confidence.

The default reservoir discharge pattern in Flood State A aims to maintain a flow of less than 540m^3/s in Cork. Discharges are calculated on the basis of flows forecast for the Shournagh and Western Bride in 2 hours' time. The FFS calculates the required discharge rate. The rate is set every 2 hours and communicated to the Reservoir Operator who implements it.

In most instances, flood events will be significantly smaller than the design event, and it will not be necessary to regulate the Lee at 540m^3/s in Cork. A smaller fixed discharge will reduce flows in the city and retain water in the reservoirs. The FFS will automatically calculate the discharge rate required from Carrigadrohid and Inniscarra to achieve FRL in 48 hours. The Flood (Advisory) Body can also use the FFS to run 'what if' scenarios to determine the impacts of alternative discharge patterns.

The results will inform a decision on whether to adopt the fixed discharge rate, or to regulate according to the default mode of operation.

At this stage of the event, all operations and forecasts are reviewed every two hours. Fixed discharge patterns are only adjusted if there is a need for a change greater than 25m^3/s.

Flood State State A ends when:

- Inflows to the reservoirs have peaked (for the main event) and are falling.
- Water levels are at or below FRL.
- Water levels are falling in Cork (and are forecast to continue falling).
- No further threshold crossing is forecast in the next 96 hours.

Once invoked, other Flood States are only cleared when the forecast maxima drops 10% below the relevant threshold.

6.5.5 Flood State F

If the event peak is forecast at less than 400m^3/s in the 3 hour time window then it will almost certainly not require full regulation. It is a FALSE ALARM and the system enters Flood State F to manage it.

In Flood State F, the aim is to manage the reservoirs back to FRL. The FFS will simulate the discharge rate needed to achieve this. This discharge pattern will be implemented and reviewed every 2 hours (or as necessary).

6.5.6 Flood State Summary

Table 5 below summarises the proposed flood states, actions and frequencies for the proposed revised dam operations.

Table 5: Flood States, Actions and Frequencies

Flood State Ref.	**Description of Flood State (Trigger)**	**General Action Required (Dam Discharge)**	**Envisaged Frequency of Occurrence po st-scheme**	**Historic Frequency of discharges (based on review of last 10 years of record)**	**Notes**
D	Between 96 and 48 hours before inflows to Carrigadrohid predicted to exceed 180m^3/s;	Draw reservoirs down to Flood Risk Level (FRL), based on rate calculated by FFS, not normally exceeding 150m^3/s from Inniscarra	Likely to occur on average up to **10 to 15 days per year.**	For 100 days over last 10 years, discharges exceeded 150m^3/s so 10 days per year on average	Negligible change envisaged in frequency of discharges up to 150m^3/s.
C	Between 48 and 24 hours before inflows to Carrigadrohid predicted to exceed 285m^3/s;	Discharge up to **200m^3/s** from Inniscarra (or as close to as possible given available head at dam gates)	Likely to occur on average up to **4 days per year**.	For 33 days over last 10 years, discharges exceeded 200m^3/s so 3 days per year on average	Very marginal increase in frequency envisaged in discharges of between 150m^3/s to 200m^3/s
B	Between 24 and 3 hours before inflows to Carrigadrohid predicted to exceed 285m^3/s	Discharge up to **300m^3/s** from Inniscarra (or as close to as possible given available head at dam gates)	Likely to occur on average up to **2 days per year**.	Only one occurrence over last 10 years	Discharges between 200m^3/s and 300m^3/s will become significantly more frequent with an occurrence expected to occur once or twice per year.

Flood State Ref.	Description of Flood State (Trigger)	General Action Required (Dam Discharge)	Envisaged Frequency of Occurrence post-scheme	Historic Frequency of discharges (based on review of last 10 years of record)	Notes
A	400m^3/s threshold inflow to Carrigadrohid is crossed (or forecast to be exceeded at a short lead time of 3 hours).	Manage flow at 540m^3/s or less through Cork by adjusting Inniscarra discharge allowing for predicted inflow from downstream tributaries. Discharge from Inniscarra likely to be between **300m^3/s and 400m^3/s**	Likely to occur on average, **once every 3 to 5 years**	Only one occurrence over last 10 years	Minor increase in the frequency of such discharges as this will only occur around the peak of extreme events.

6.6 Design Exceedence Event

Like all flood relief schemes, the Lower Lee scheme is designed to provide protection to a defined standard, namely the 1% AEP fluvial standard more commonly referred to as the 1 in 100 year flood. This is an internationally recognised flood protection standard which has been adopted in Ireland and used in all of the major urban flood relief schemes such as Mallow, Clonmel and Kilkenny.

There remains a residual risk of flood events in excess of this standard and which therefore are beyond the design scope of the Scheme. These are known as Design Exceedence Events.

In the case of the Lower Lee Scheme, such a scenario arises when an event occurs that results in water levels in the reservoirs reaching levels where ESB’s dam safety rules require discharges which are greater than can be retained within the downstream flood defences and which will result in some flooding downstream.

Whilst the revised reservoir operating rules and direct defences will significantly reduce the magnitude and impact of such a scenario, emergency measures will still be absolutely essential.

In such a scenario, existing Major Emergency Management protocols will be implemented by Cork local authorities and other emergency response agencies to manage the emergency response in Cork.

6.7 Roles and Responsibilities

There are two primary roles involved in implementing the revised operational rules, during flood conditions, as follows:

- Flood (Advisory) Body, the OPW through its agents* fulfilling the role required under the Lower Lee (Cork City) Drainage Scheme.
- Reservoir Operator – Electricity Supply Board (ESB)

**It is envisaged that Cork City Council will act as agents for the OPW in carrying out the functions of the Flood (Advisory) Body*

Flood Forecasting System: As an integral and essential element of the new scheme, a Flood Forecasting System (FFS) has been developed and will be introduced to enable the putting into effect and operation of the new dam operating procedures.

It is envisaged that in virtually all cases, the dam discharge pattern to be followed will be that determined by the FFS, which has an inbuilt function to calculate the required discharge rates to draw down the reservoirs to the required level at a given time and/or to ensure that the peak flow in Cork is less than the 1% AEP design flow. Only in very exceptional cases, and with good reason, would an alternative strategy be followed following consultation between the Flood (Advisory) Body and the Reservoir Operator.

The Flood (Advisory) Body will:

- Operate, monitor and maintain the FFS.
- Confirm when ‘flood conditions’ are in force (based on predictions from the FFS).
- Liaise with the Reservoir Operator, and advise the pre-documented dam discharge strategy to be followed, based on the output from the FFS (or in exceptional cases, in collaboration with the Reservoir Operator, advise an alternative discharge strategy if there is a clear justification for same).

The Reservoir Operator will:

- Implement the advised dam discharge strategy from the FFS.
- In exceptional circumstances, following consultation with the Flood (Advisory) Body, implement an alternative discharge strategy.
- At all times other than during ‘flood conditions’, operate the reservoirs for hydropower generation in accordance with their normal operating procedures.
- Control and operate the reservoirs in accordance with its current dam safety rules, where during a design exceedence event, reservoir levels exceed levels requiring higher discharges for dam safety purposes.
- The Reservoir Operator will also have access to the FFS.

7 Flood Forecasting and Early Warning System

A flood forecasting and early warning system can play a significant 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 a flood event.

The Flood Forecasting System (FFS) proposed for the Lower Lee would use forecasted rainfall in lead up to event as well as real time data during event.

It will run continuously, monitoring for potential extreme events.

It will provide an alarm to the operator, a number of days out, when a predicted significant event is above a predefined threshold that could otherwise result in flooding.

This will allow dam levels to be lowered at predefined spill rates which won't flood property (buildings), in preparation for/anticipation of the extreme event. The dam discharge pattern to be followed will be that determined by the FFS, which has an inbuilt function to calculate the required discharge rates.

It will allow management of discharges in real time (if required) taking account of inflow from the Shournagh/Bride and tide levels.

Trigger levels are set conservatively low to ensure that large events are caught. The trigger levels allow for the greater uncertainty at longer lead times.

There will be some false alarms, but these will serve an important training function.

The Flood Warning System would be utilised for a number of purposes:

- Warning of increased advance discharges for recreational users of river and floodplain amenities downstream of Inniscarra.
- Warning to landowners of washland areas to allow livestock to be relocated.
- Warning to Cork City Council to close flood gates if necessary and
- Emergency Response Planning.

The Flood Warning System dissemination would include the following:

- Direct notification to landowners of washland areas.
- Sirens in public amenity floodplain areas.
- Local Authority websites and social media platforms.
- Local Authority 'text alert' system and
- Radio and television public alerts if necessary.

8 Creation of Washlands

Washlands areas upstream of Cork City will be designated as part of the scheme.

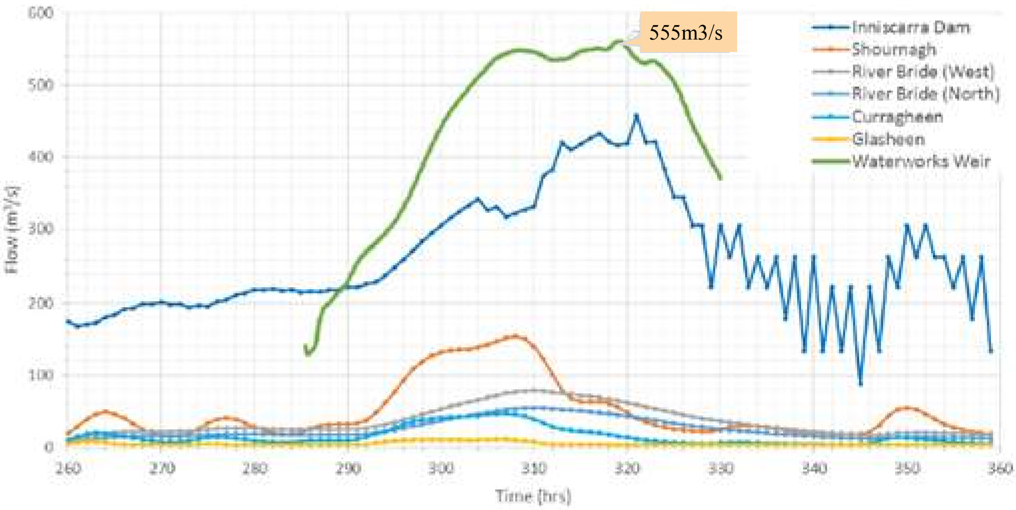
“Washlands” are those areas adjacent to the river (and part of the Lee floodplain) which under the Scheme, will be deliberately flooded in advance of a forecasted extreme event, to facilitate pre-emptive lowering of water levels in Carrigadrohid and Inniscarra reservoirs, to create additional storage/attenuation capacity, and subsequently reduce the peak flow during the event.

This measure in conjunction with the optimised dam procedures would allow for greater discharges (without causing flooding of properties) in advance of a forecast event.

It is proposed that these designated flood plains would facilitate advance discharges of up to 300m^3/s from the dams.

The flow from the dams can therefore be regulated, thus reducing the peak flow to approximately 555m^3/s (as shown in Figure 12) in the urbanised areas from Carrigrohane Road to Cork City centre.

Figure 12: Design Peak Flows for the Design Event (1 in 100 year).



The proposed washlands areas have been identified and are illustrated in Figure 13 to Figure 14 below.

In designating these washlands, to allow pre-emptive advance spilling of water from the reservoirs at higher rates, it is recognised that ‘artificial’ or ‘early’ flooding of existing floodplains will occur. As can be seen, this will predominantly affect agricultural land to the west of the city. These lands will benefit from the scheme in terms of a reduction in the peak flows and thus magnitude of flooding from extreme events.

However, as a result of the pre-emptive spilling of higher flows from the dams, these lands will be subject to a greater frequency of lower or medium flooding events.

In addition, the proposed scheme will result in peak flows extending for a longer duration during a given flood event. The works will therefore impact on the use of these lands.

Changes in frequency of flooding of these washland areas can be seen by reference to Table 5.

Figure 13: Upstream Washlands – Inniscarra

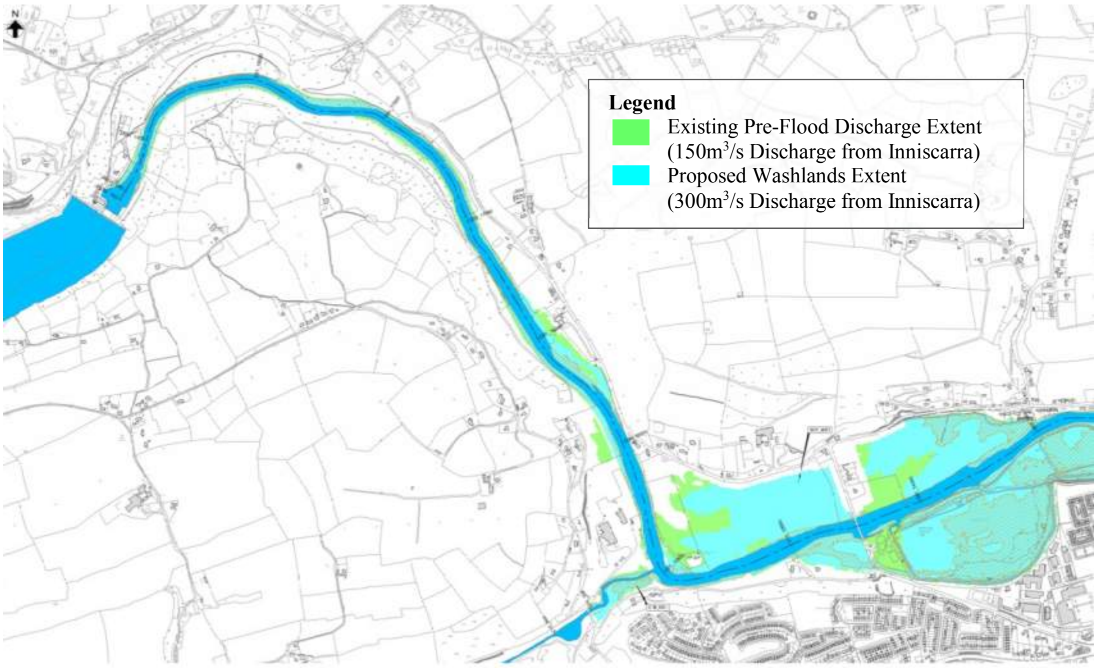


Figure 14: Upstream Washlands – Ballincollig/Leemount

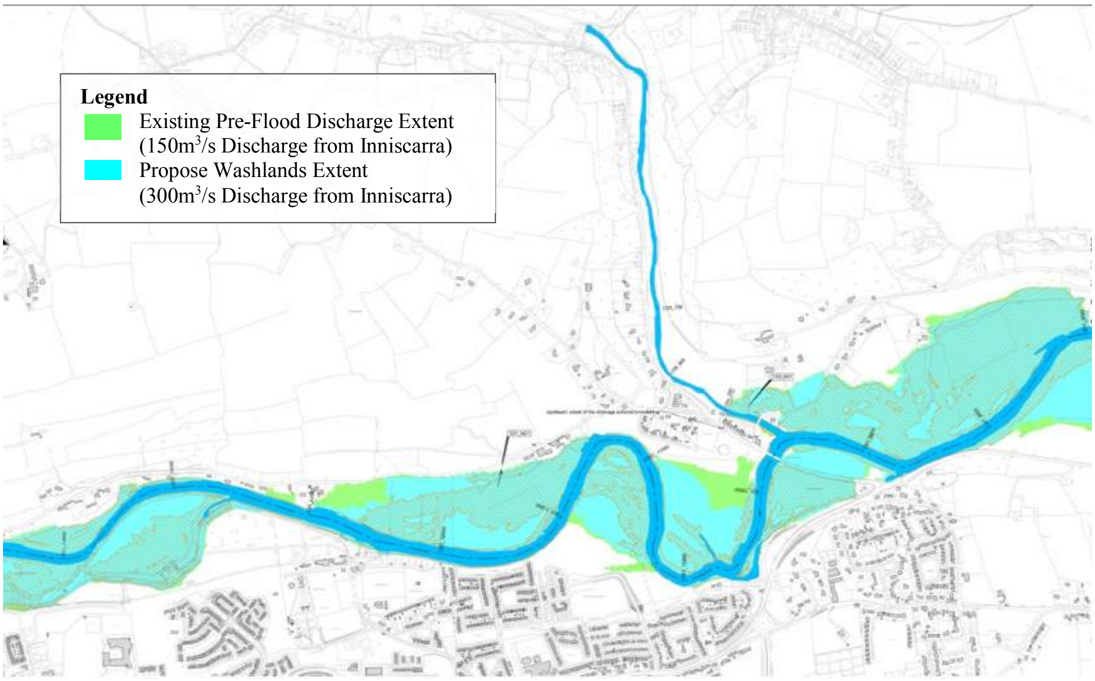
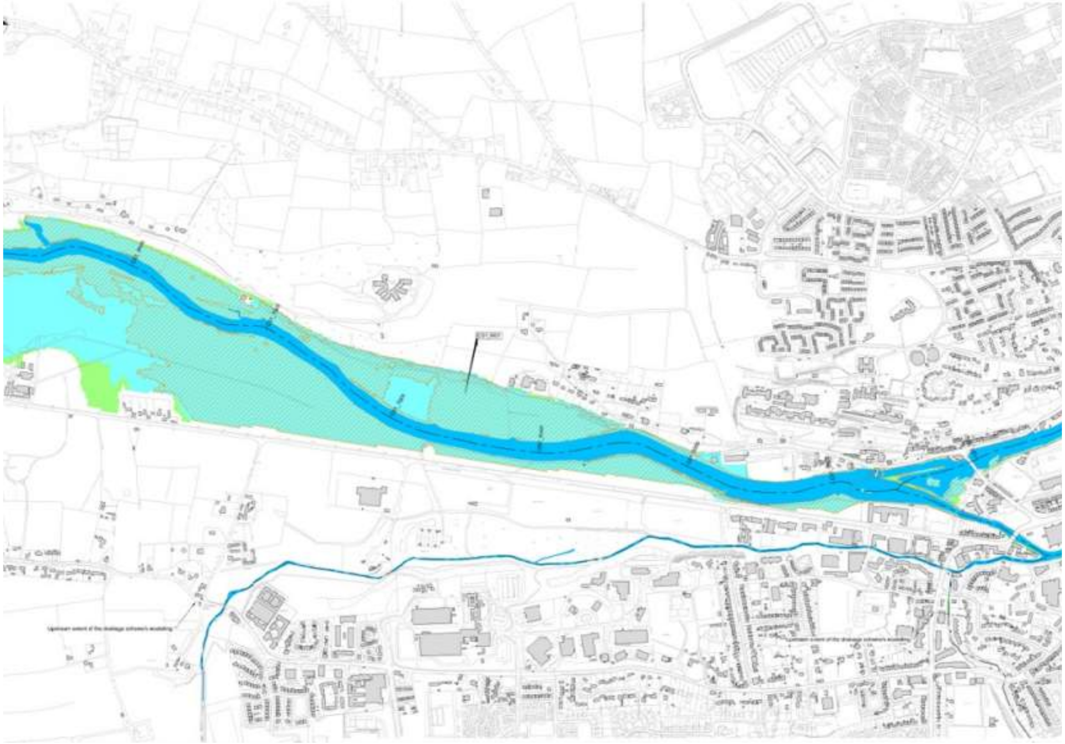


Figure 15: Upstream Washlands – Carrigohane Rd



9 Upstream Flood Storage

9.1 Introduction

This section outlines the assessment undertaken of the feasibility of implementing ancillary flood storage, individually and in combination, on the tributaries of the River Lee within the study area.

Significant environmental constraints exist for this option, in that any structure on the river could affect aquatic life and in particular salmon spawning areas. The footprint of the flooded areas would be largely sterilized, and the storage area and dam would have ongoing maintenance requirements.

Given the presence of Inniscarra and Carrigadrohid reservoirs, it is assumed that ancillary storage areas would require an active control system to ensure that the timing of the releases could be managed in conjunction with the releases from the existing dams, to ensure storage was available when most needed to maximise the benefit in Cork.

Notwithstanding this, it is considered that the effectiveness of ancillary storage areas will be limited due to the relative timing of the peaks of the individual flood events.

Since the tributaries have much smaller catchments that the main River Lee, the time to peak of the tributary catchments are significantly shorter than that of the Lee. This phenomenon can be seen in Section 2.3 of the Lower Lee Hydraulic Modelling Report.

Therefore, even if a significant reduction in peak flow on the tributaries is achievable, the critical event that produces the design flow at Cork City may not be significantly reduced.

The following tributary catchments were reviewed for potential storage areas using the LiDAR digital terrain model:

- River Bride (West)
- River Shournagh

9.2 Analysis of Fluvial Flood Volume at Cork City

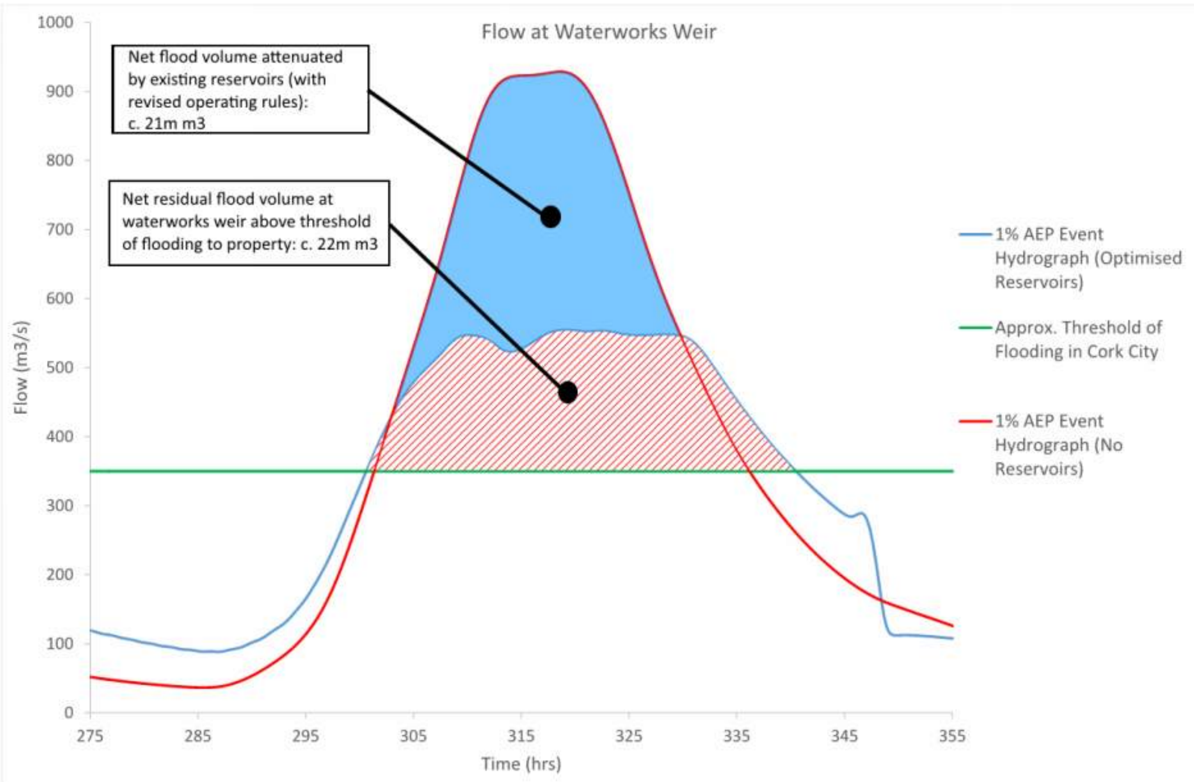
In order to give some context to the scale of additional storage required in order to make an appreciable difference to fluvial flood levels in Cork, the flood hydrographs at waterworks weir were analysed. Based on this analysis, the following was noted:

- The existing reservoirs (with revised operating rules during flood conditions) can reduce/attenuate the peak of the 1% AEP flood event by circa 21 million m^3 at waterworks weir (compared with the theoretical scenario where the existing reservoirs do not exist). Note that this volume reduction is less than the actual storage volume mobilised in the reservoirs during this event (circa 35 million m^3). The difference between the attenuated volume and volume of storage available at the dams is a function of the phenomenon whereby the effectiveness of the upstream flood storage diminishes as the distance downstream increases, the inefficiencies associated with dams constructed in series and the operational restrictions of the dams.

- In the design scenario (existing dams with revised operating rules), the residual flood volume above the threshold at which property would begin to flood (approximately $350m^3/s$ flow) is circa 22 million m^3. This is the volume that would need to be attenuated by further storage in order to remove the need for raised flood defences in Cork City. However, the CIRIA report *Design of Flood Storage Reservoirs* (Hall, Hockin and Ellis (1993)), suggests that where reservoirs are constructed in series, the storage is typically 0.7 – 0.8 times that of one reservoir of the same size. Where reservoirs are constructed in parallel, the interaction is more complex. Therefore, as any viable solution is likely to require multiple reservoirs within the Lee catchment, it is reasonable to allow a factor of 0.6 for the inefficiencies associated with multiple reservoirs in both series and parallel. This would result in an additional volume of storage of circa 37 million m^3 being required to attenuate the flow to $350m^3/s$ at waterworks weir. In practical terms, this is the equivalent of the storage available at the existing Carrigadrohid and Inniscarra reservoirs.

The above analysis is demonstrated in Figure 16 below.

Figure 16: Analysis of hydrographs at Waterworks Weir



9.3 Assessment of Potential Ancillary Flood Storage on River Bride (West)

The peak flow on the River Bride (West) at Ovens during the design flood event is approximately $83m^3/s$. At this location, the overall volume of the design flood hydrograph is in the order of 11.5 million m^3. Substantial storage capacity at a suitable location on the river would be required in order to achieve a significant reduction in flow downstream. Two potential locations (Figure 17) on the River Bride (West) were assessed in this regard:

A. Upstream of Killumney Village

B. Upstream of Farren Cross

Figure 17: Upstream Storage Areas Considered for River Bride West

A. Upstream of Killumney Village

This potential storage area is located on a region of pastoral land just upstream of Killumney Village. There is the potential for approximately $96,000m^3$ of storage up to the 33mOD contour. The footprint of the storage area would be approximately 9 hectares. The area of catchment upstream of this point is $110km^2$ (circa 10% of the Lee catchment to Waterworks Weir).

The main elements of the construction works required are illustrated on Figure 18 below and can be summarised as follows:

- Construction of a new dam (incorporating flow control structure) of maximum height approximately 4-6m

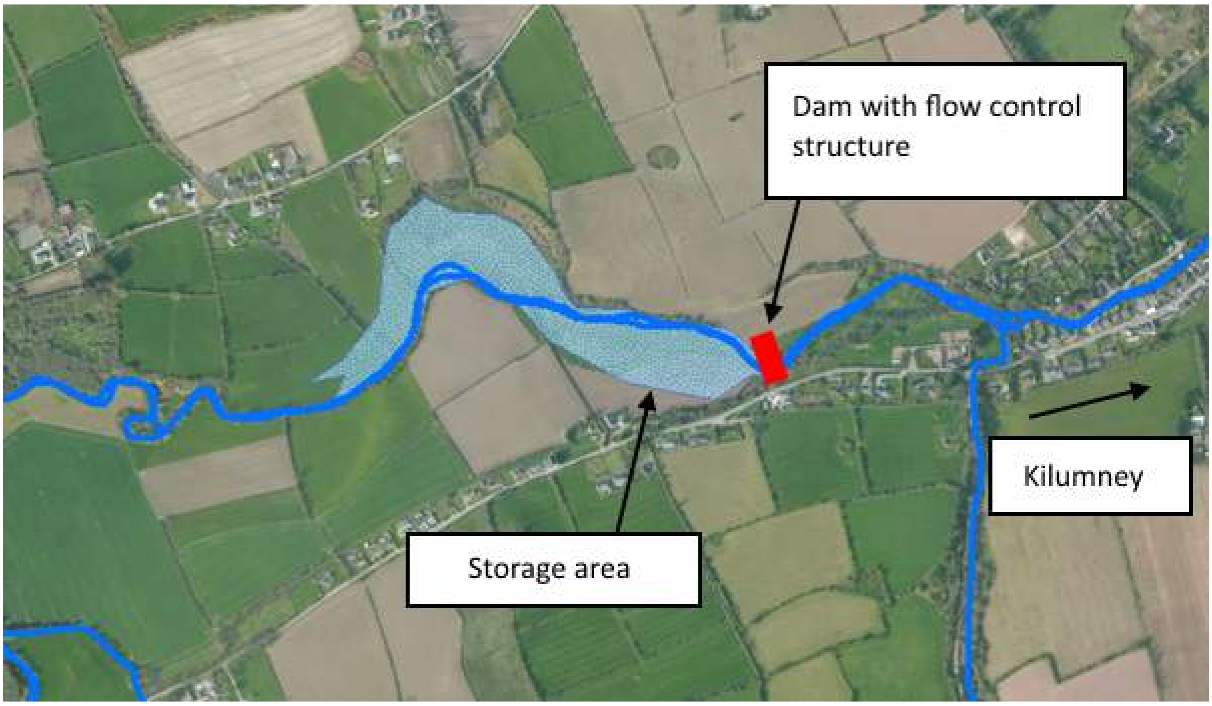
A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	$82.6m^3/s$
Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	$77.5m^3/s$

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case 1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

The potential reduction in peak flow, while beneficial, is considered to be insignificant in the context of the design flow at Cork City. Therefore this potential storage area was not assessed further.

Figure 18: Potential Upstream Storage Area upstream of Killumney Village



B. South of Farran Cross

This potential storage area is located on a region of pastoral land south of Farran Cross. There is the potential for approximately 850,000m^3 of storage up to the 39.8mOD contour. The area of catchment upstream of this point is 99km^2 (or 9% of the Lee catchment to Waterworks Weir)

The main elements of the construction works required are illustrated on Figure 19 below and can be summarised as follows:

- Construction of a new dam (incorporating flow control structure) of maximum height approximately 4-6m
- A significant proportion of the land in this storage area is inundated in the existing case 10% AEP event. Therefore, in order to ensure that the storage area would not be prematurely filled in advance of the peak of the design flood, it would be necessary to construct flood defence embankments along the river banks within the storage area. Considering that the underlying soil is known to consist of gravels, it is also likely that cutoff would be required beneath the embankments. The flood defence embankments would need to be designed such that they would only begin to overtop once the limiting flow is reached. Return sluices would be required to drain the area.
- The footprint of the storage area would be approximately 3km^2. The storage area contains 10no. residential properties and 1no. commercial property. In order to prevent inundation of these properties during times when the storage area is filled, it would be necessary to raise the existing north-south road, along with construction of direct defences around these properties. Alternatively, these properties could be compulsorily acquired and demolished.

  The remainder of the land within the storage area is currently used for agriculture. The productivity of this land would be impacted as a result of construction of this storage area.

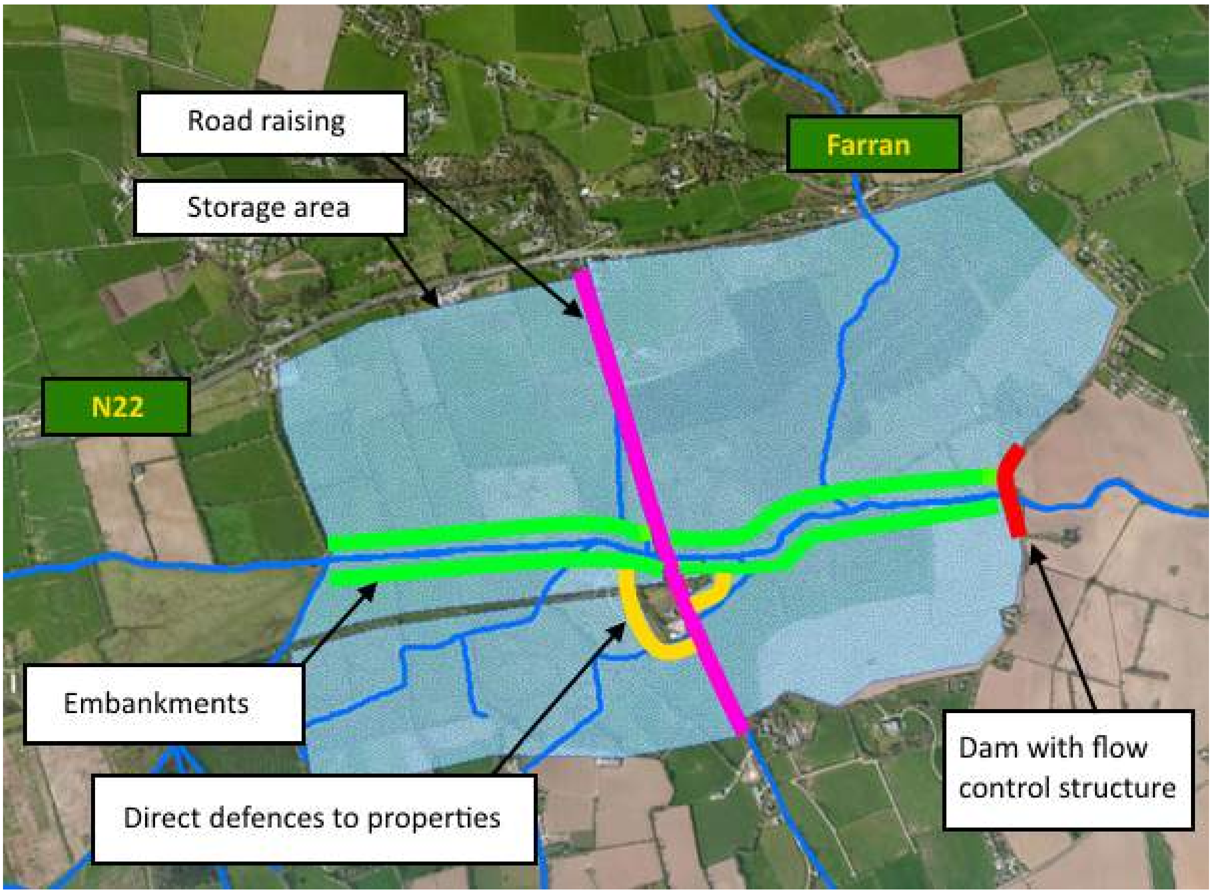
A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	74.3m^3/s
Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	55m^3/s

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case

1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

Figure 19: Potential Upstream Storage Area upstream of Farren Cross



It can be seen that this potential storage area could reduce the peak flow on the Bride by circa 20m3/s. However, not all of this reduction would accrue in Cork City and in any event, a 20m3/s reduction in Cork would only marginally lower required defence heights to the west of the city. In this context, it is considered that the scale, cost and disruption of the storage area could not be justified.

9.4 Assessment of Potential Ancillary Flood Storage on River Shournagh

The peak flow on the River Shournagh at Healy's Bridge during the design flood event is approximately 177m^3/s. At this location, the overall volume of the design flood hydrograph is in the order of 40 million m^3. Substantial storage capacity at a suitable location on the river would be required in order to achieve a significant reduction in flow downstream.

The topography of the lower Shournagh valley (between Leemount Cross and Healy's Bridge) would appear to be potentially suitable for flood storage. However, this reach currently has a significant number of residential properties (circa 30no) which would need to be acquired and demolished if any storage area were to be constructed in this reach. Furthermore, there would be potential for the operation of the storage area to be affected by the backwater from the River Lee during extreme events. Therefore, storage in this reach is not considered to be justifiable and was ruled out.

Four potential locations (Figure 20) in the catchment of the River Shournagh upstream of Healy's Bridge were assessed in further detail:

A. Upstream of Healy's Bridge

B. Tower Village

C. Upstream of Bawnafinny Bridge on the Blarney River

D. Upstream of Gothic Bridge on the Blarney River

Figure 20: Upstream Storage Areas Considered for River Shournagh

A. Upstream of Healy's Bridge

This area is located just upstream of Healy's Bridge on the Shournagh River. This area could provide approximately 1.2 million m^3 of storage up to the 21.5mOD contour. The area of catchment upstream of this point is 211km^2 (circa 19% of the Lee catchment to Waterworks Weir).

The main elements of the construction works required are illustrated on Figure 21 below and can be summarised as follows:

- Construction of a dam with maximum height of approximately 9m, incorporating a flow control structure.
- Reconstruction of approximately 3km of the R579 regional road on a different alignment and at a higher elevation, possibly including reconstruction of Healy's Bridge.
- Approximately 7 no properties would need to be compulsorily acquired and demolished. Several further properties which are accessed from the existing R579 would need to be provided with alternative access roads. (Alternatively, these properties could also be acquired).

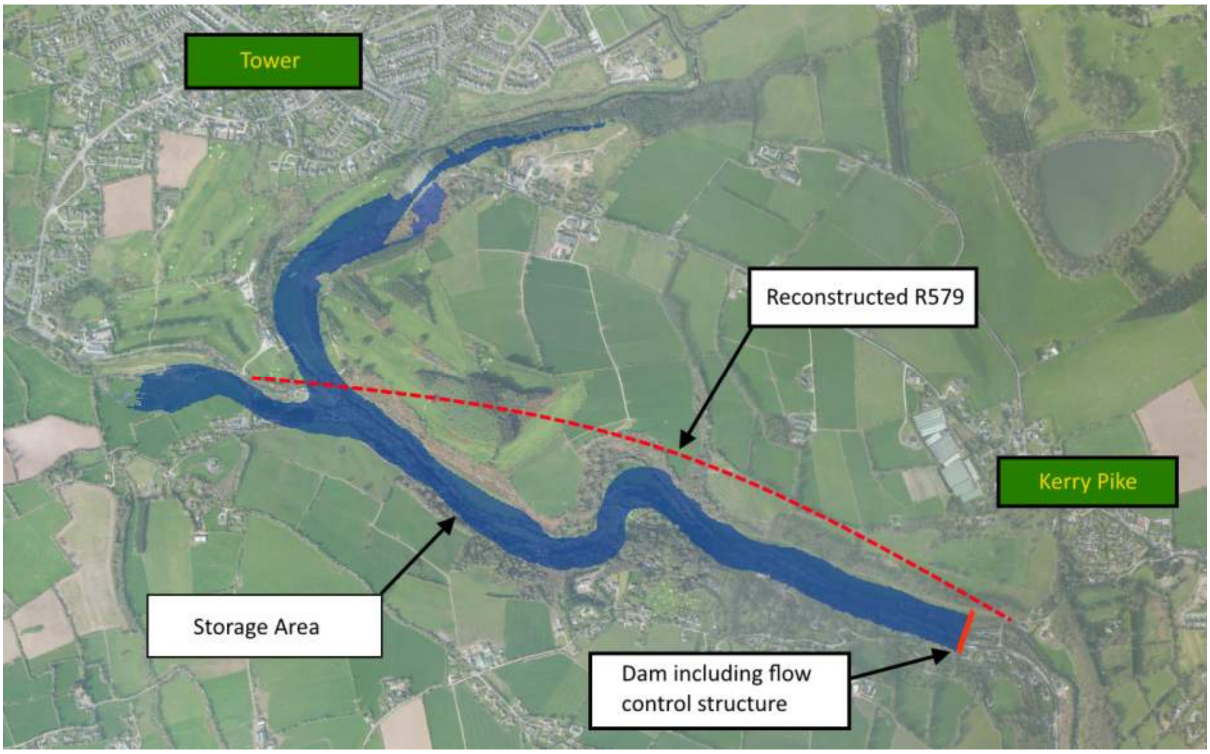
The area of the storage area created would be approximately 0.5km^2, consisting of a significant quantity of farmland and part of a local golf course (likely resulting in closure of same).

A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	177.2m^3/s
Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	118m^3/s

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case 1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

Figure 21: Potential Upstream Storage Area Upstream of Healy's Bridge



It can be seen that this potential storage area could reduce the peak flow on the Shournagh by circa $60m^3/s$. However, not all of this reduction would accrue in Cork City and in any event, a $60m^3/s$ reduction in Cork would only lower the already relatively low defence heights to the west of the city by circa 300mm on average. In this context, it is considered that the very significant scale, cost and disruption of the storage area could not be justified.

Furthermore, the construction of such a large storage area would introduce a new residual risk to the residential properties downstream associated with potential dam overtopping or breach.

B. Tower Village

This area is located just downstream of the confluence of the Shournagh and Blarney Rivers just outside the village of Tower. This area could provide approximately $113,000m^3$ of storage up to the 25mOD contour. The area of catchment upstream of this point is $161km^2$ (circa 15% of the Lee catchment to Waterworks Weir)

The main elements of the construction works required are illustrated on Figure 22 below and can be summarised as follows:

- Construction of a dam with maximum height of approximately 3m, incorporating a flow control structure.
- A significant proportion of the land in this storage area is already part of the floodplain of the Shournagh. Therefore, in order to ensure that the

storage area would not be prematurely filled in advance of the peak of the design flood, it would be necessary to construct flood defence embankments along the river banks within the storage area. The flood defence embankments would need to be designed such that they would only begin to overtop once the limiting flow is reached. Return sluices would be required to drain the area.

- Possible flood defence embankments around the existing wastewater treatment plant and Willison Park housing estate to ensure sufficient freeboard above the design storage level.

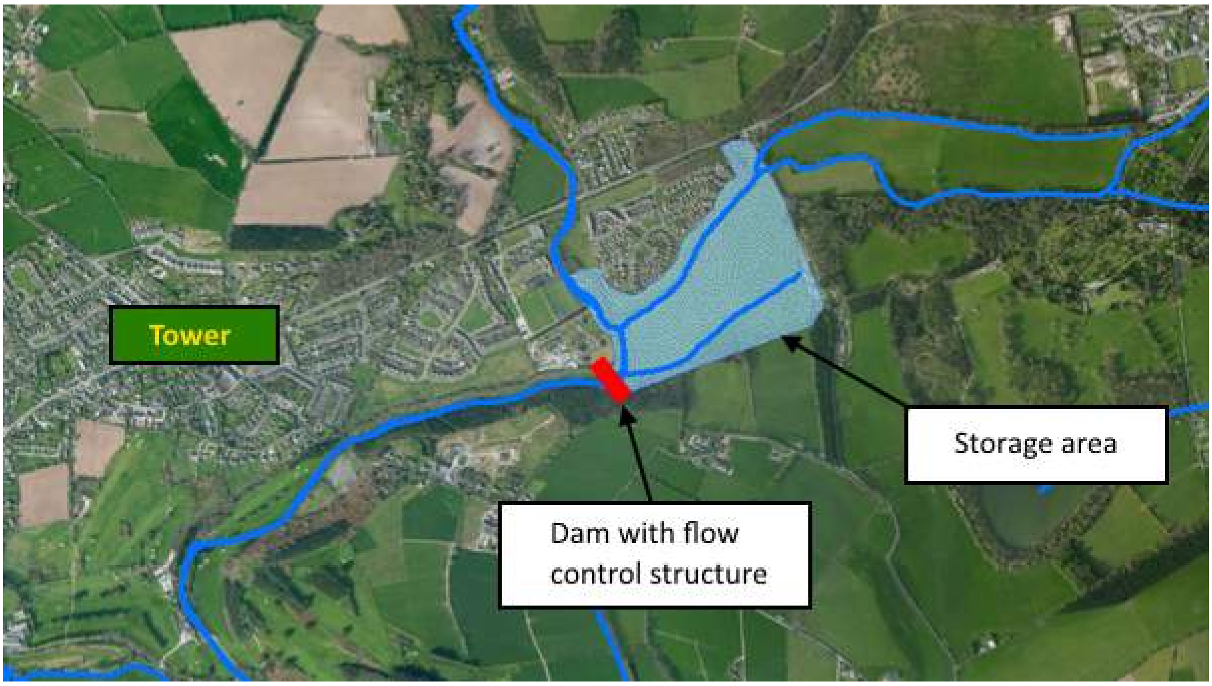
The plan area of the storage area created would be approximately $0.25km^2$, consisting of pastoral land and forestry.

A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	$147.1m^3/s$
Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	$135m^3/s$

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case 1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

Figure 22: Potential Storage Area Downstream of the confluence of the Shournagh and Blarney Rivers in Tower Village



The potential reduction in peak flow, while beneficial, is considered to be insignificant in the context of the design flow at Cork City. Therefore this potential storage area was not assessed further.

C. Upstream of Bawnafinny Bridge on the Blarney River

This area is located upstream of Bawnafinny Bridge on the Blarney River. This area could provide approximately 298,000m^3 of storage up to the 28mOD contour. The area of catchment upstream of this point is 90km^2 (or 8% of the River Lee catchment to Waterworks Weir).

The main elements of the construction works required are illustrated on Figure 23 below and can be summarised as follows:

- Construction of a dam with maximum height of approximately 3m, incorporating a flow control structure.
- Some localised raising of the R617 regional road raising over a length of approximately 500m.

The plan area of the storage area created would be approximately 0.3km^2, consisting primarily of agricultural land.

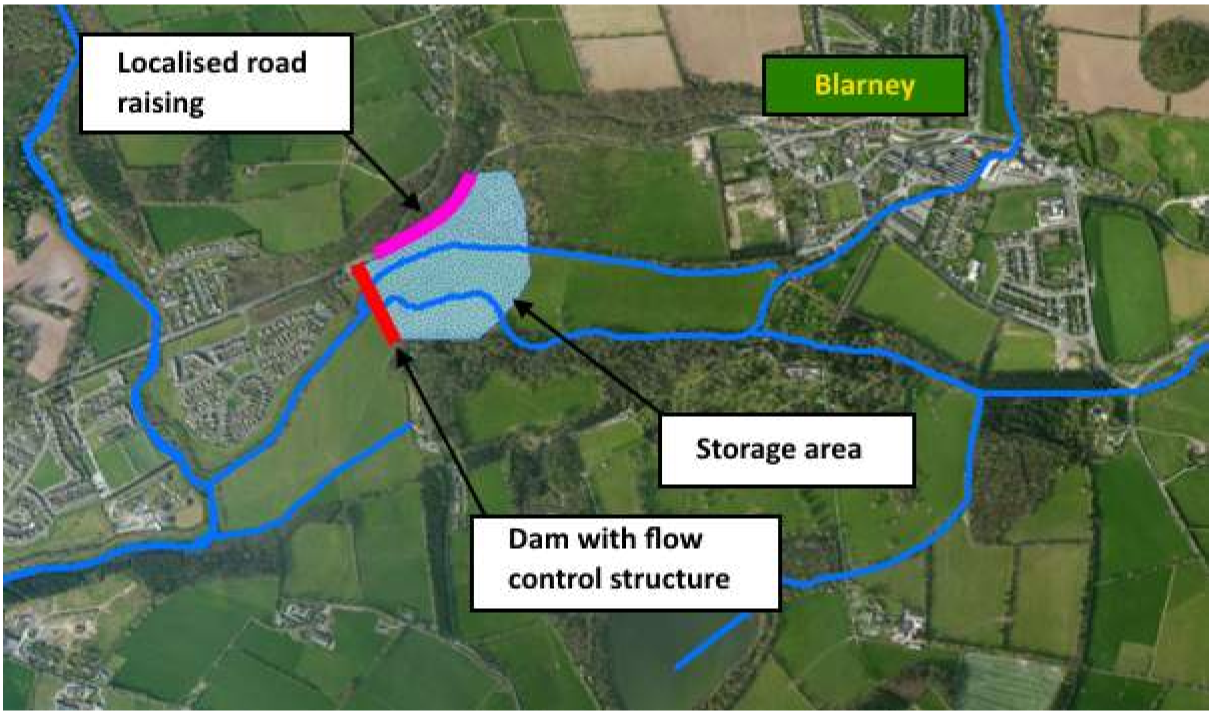
A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	78.8m^3/s

Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	60m^3/s

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case 1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

Figure 23: Potential Upstream Storage Area Upstream of Bawnafinny Bridge



D. Upstream of Gothic Bridge on the Blarney River

This area is located upstream of Gothic Bridge on the Blarney River. This area could provide approximately 458,000m^3 of storage up to the 30mOD contour. The area of catchment upstream of this point is 21km^2 (or 2% of the Lee catchment to Waterworks Weir)

The main elements of the construction works required are illustrated on Figure 24 below and can be summarised as follows:

- Construction of a dam with maximum height of approximately 2-3m, incorporating a flow control structure.

- A significant proportion of the land in this storage area is already part of the floodplain of the Shournagh. Therefore, in order to ensure that the storage area would not be prematurely filled in advance of the peak of the design flood, it would be necessary to construct flood defence embankments along the river banks within the storage area. The flood defence embankments would need to be designed such that they would only begin to overtop once the limiting flow is reached. Return sluices would be required to drain the area.

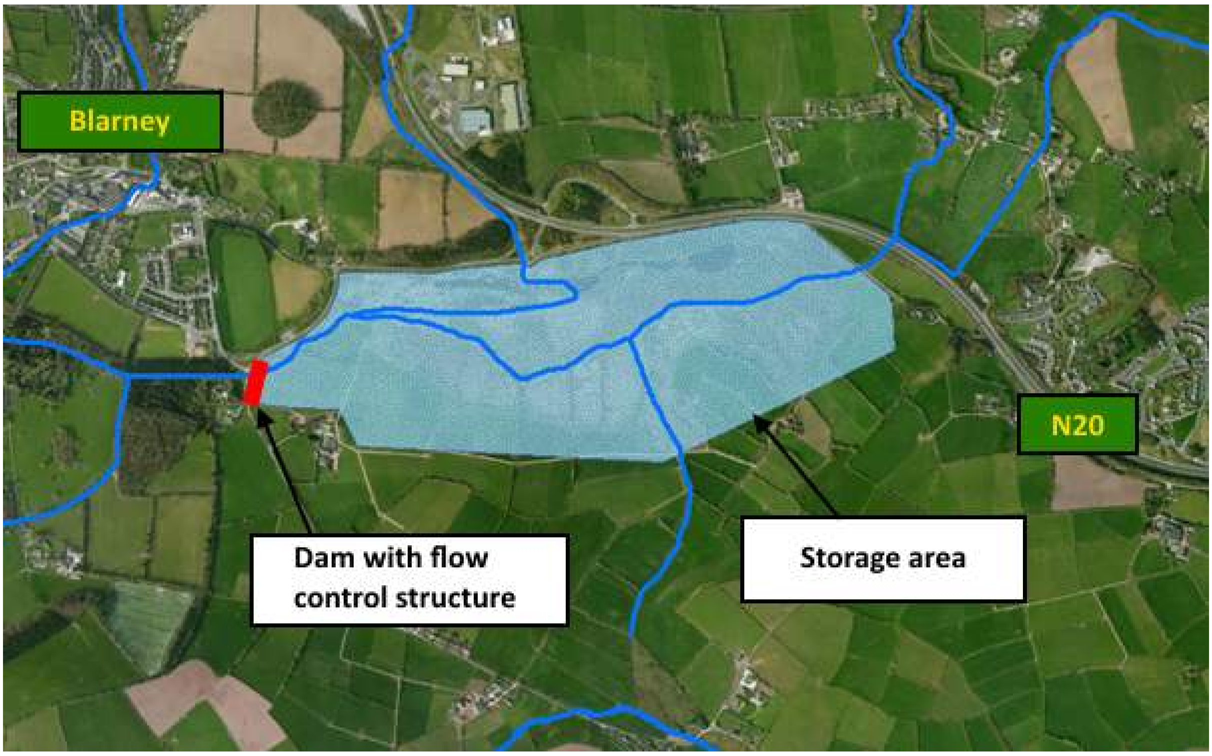
The plan area of the storage area created would be approximately 1.1km^2, which currently consists primarily of wetland.

A preliminary analysis of the potential achievable reduction in peak flow was carried out, which suggested the following:

Approximate existing peak flow at storage area location during design event	20.7m^3/s
Possible attenuated peak flow immediately downstream of the storage area during the design flood event*	7m^3/s

* Note that this flow reduction would not directly translate to the same reduction in flow at Cork City. This is because in the proposed case, the 1% AEP flood event at Cork could potentially be generated from a different combination of events on the other subcatchments. In this scenario, it is possible that the events on the other subcatchments may have a greater peak flow than in the existing case 1% AEP event. This would erode the net benefit of the storage area for reducing peak flow in Cork.

Figure 24: Potential Upstream Storage Area Upstream of Gothic Bridge



The potential reduction in peak flow, while beneficial, is considered to be insignificant in the context of the design flow at Cork City. Therefore this potential storage area was not assessed further.

9.5 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.

The CIRIA report Design of Flood Storage Reservoirs (Hall, Hockin and Ellis (1993)), suggests that where reservoirs are constructed in series, the storage is typically 0.7 – 0.8 times that of one reservoir of the same size. Since each potential storage area discussed above have been ruled out individually, it is considered unlikely that multiple storage areas on the same tributary would produce a favourable result.

The *Design of Flood Storage Reservoirs* states that when flood storage reservoirs are constructed in parallel, the interactions between them is complex. The report also notes that it is important to have an understanding of the relative timing of the peaks of each of the events on each subcatchment. Within the area under consideration, lack of historical gauged data on the spatial variation of rainfall across the catchment limits the ability to optimise the design of such a solution. In order to remove this uncertainty, a significant period of further gauged tributary flows and local subcatchment rainfall data would be required.

Notwithstanding the above, it should be remembered that ancillary storage on the tributaries cannot eliminate the requirement for the following works:

- Tidal defences in the eastern part of Cork City,
- Defences to the west of Cork city associated with advance discharges from Inniscarra dam,
- Requirement for raised defences to deal with the residual risk along the fluvially-dominated reach downstream of waterworks weir.

Should all of the above storage areas be constructed, it is noted that it would only provide a total combined volume of circa 3 million m^3 of the circa 36 million m^3 required to eliminate the need for fluvial flood defences to the west of Cork City. Such a combination of storage areas in parallel and series would also require a very complex control system with an increased risk of error.

There is also a significant cost associated with the construction of the storage areas which would require fresh land purchase, including the compulsory purchase of at least 17 no. residential and 1 no. commercial property, and significant construction and maintenance costs.

Also, the provision of new flood storage areas in the Shournagh and Bride catchments, upstream of Cork City, would result in an increased flood risk in the areas in the vicinity of the reservoirs. There would be a significant residual risk associated with the dams and embankments required to mobilise the required storage due to the potential breach of the structures. This would essentially transfer some of the residual risk from Cork City to the communities in the upstream catchment. However, the residual risk would still be present downstream as the storage areas do not have sufficient volume to eliminate the need for fluvial defences in the city.

Therefore, following the assessment of the volume of storage available on the River Bride and Shournagh River, the cost associated with the construction of the storage reservoirs and associated infrastructure and the increased residual risk in areas not currently at risk, it is evident that the combination of ancillary storage areas will not yield a more favourable or cost beneficial option than the option of maximising the potential benefit of the existing dams at Inniscarra and Carrigadrohid and the construction of reasonable height direct defences downstream.

10 Assessment of Potentially Viable Structural Measures

The potentially viable structural measures considered are described in detail in the sections below.

They consist of the following:

- Direct flood defences
- In-channel flow regulation
- Local conveyance improvements
- Channel widening
- Bridge/Weir modifications
- Localised surface water pumps

10.1 Direct Flood Defences

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

10.1.1 Area 1A: Direct Flood Defences near Inniscarra Bridge

Measures considered in the vicinity of Inniscarra Bridge generally consist of direct flood defences, including flood defence walls and embankments, as shown on Figure 25 below.

Figure 25: Inniscarra Bridge Direct Flood Defences

10.1.2 Area 1B: Ballincollig/Leemount Cross Direct Defences

During extreme flood events, hydraulic modelling showed floodwaters overtopping the left bank and putting some properties to the north of the river, on the Inniscarra Road at risk. It was also shown that some properties in the vicinity of Leemount Cross are at risk during extreme events.

Measures considered in the vicinity of Ballincollig generally consist of direct flood defences, including flood defence walls and embankments, as shown on Figure 26 and Figure 27 below.

Figure 26: Direct Defences at Ballincollig

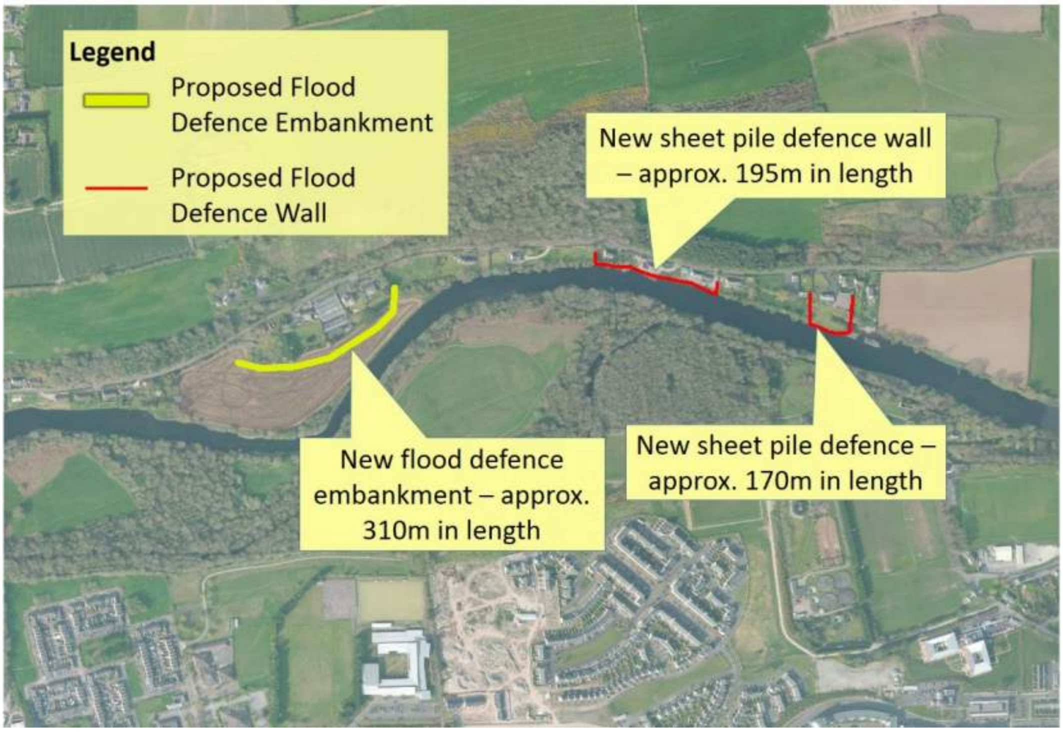
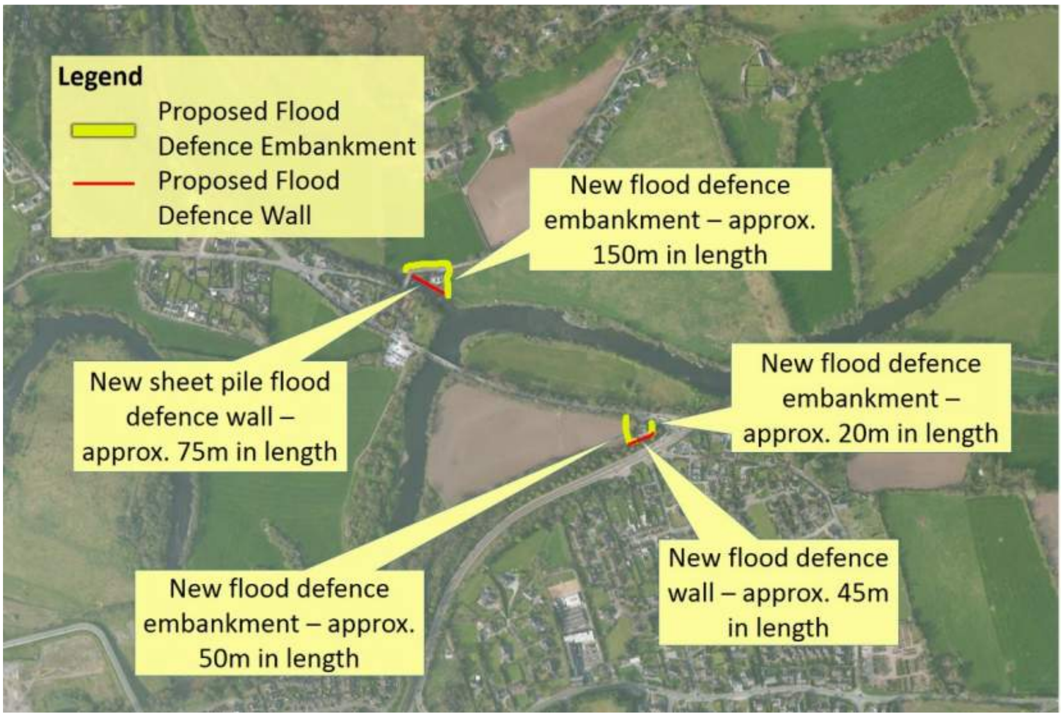


Figure 27: Direct Defences at Leemount Cross



10.1.3 Area 1C: Carrigrohane Road/Inchigaggin

Possible measures at Inchigaggin include the following as described and illustrated below.

- Direct flood defences at Inchigaggin
- Raising the N22 National Primary Road

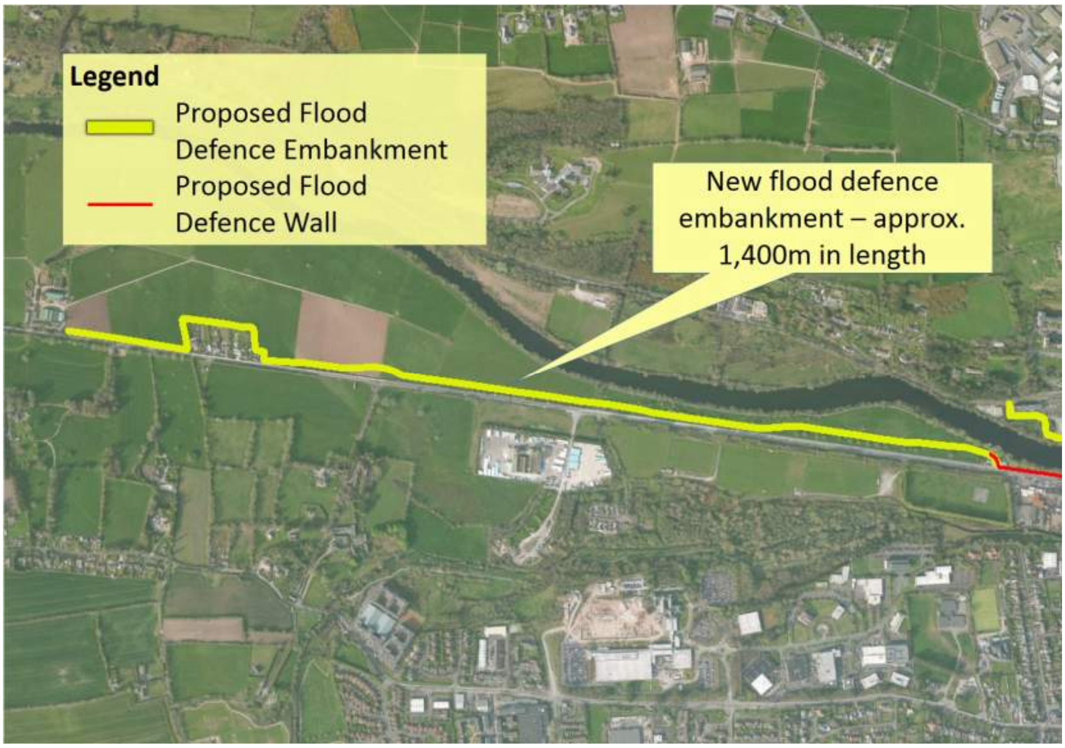
The purpose of these measures would be to prevent flow from the River Lee crossing the N22 and entering the Curragheen at Inchigaggin. They would directly defend several properties at Inchigaggin from River Lee flooding. The defence would also reduce the peak flow in the Curragheen, facilitating reduced defence heights downstream along the Curragheen and potentially the South Channel.

10.1.3.1 Measure A: Direct Flood Defences

This measure would include 1.4km of flood defence walls or embankments to the north of the N22 road as illustrated Figure 28. These defences would be located in agricultural land and give protection to properties located to the north of the N22

Capital cost would be relatively low as the majority of works would be constructed in greenfield areas.

Figure 28: Direct Defences at Inchigaggin



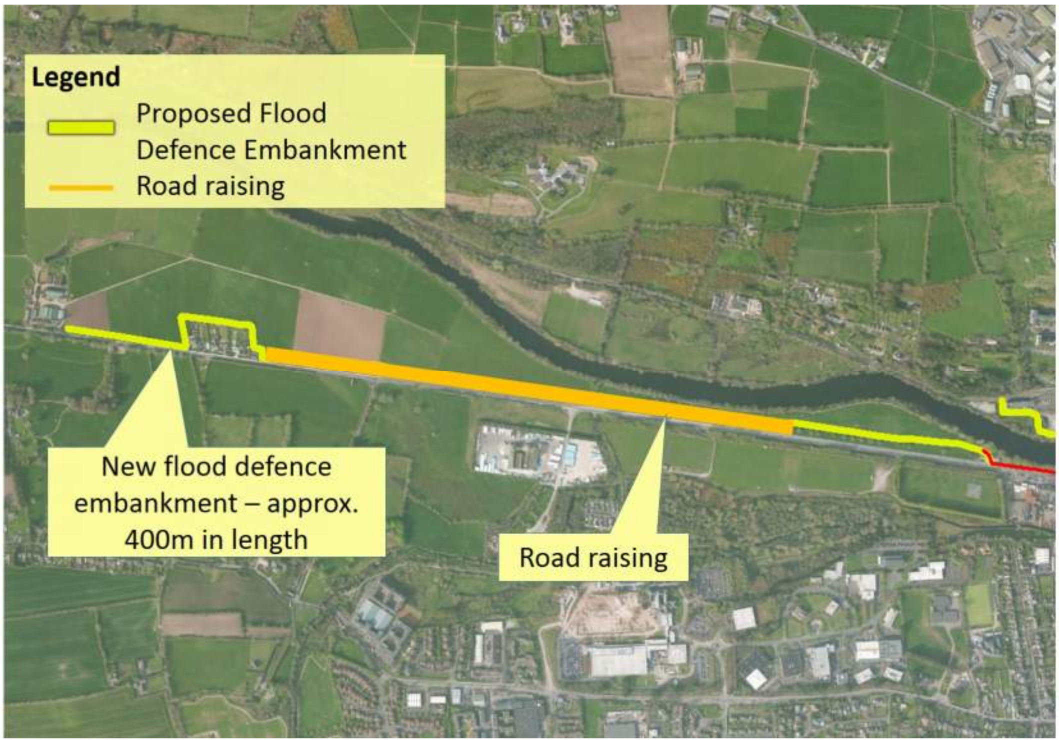
10.1.3.2 Measure B: Raising the N22 National Primary Road

As an alternative to direct defences north of the N22, this measure would involve raising approximately 1km of the N22 national road, approximately 400m of flood defence wall or embankment around properties north of the N22, modifications to existing services and possible modifications to existing land drainage. This is illustrated in Figure 29 below.

This measure would have a minimum impact on agricultural land to the north of the N22 and would likely have an insignificant impact from a landscape and visual perspective.

However this measure would have significant impact on traffic during construction and would be significantly more expensive that Measure A.

Figure 29: Carrigrohane Road Raising at Inchigaggin



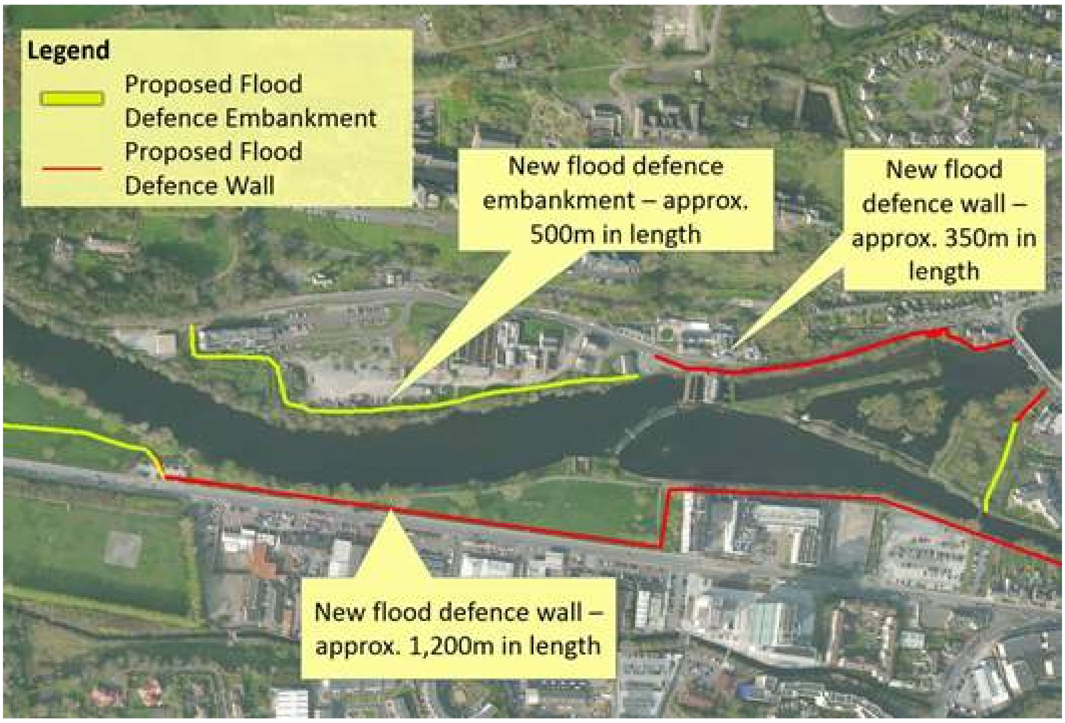
10.1.4 Area 1D: Direct Defences at Victoria Cross

This measure would include approximately 1.2km of new defence wall/embankment along the N22, extending east to the north of the Kingsley hotel towards the confluence of the South Channel and the Curragheen. The existing access to the Lee Fields would be replaced by a ramped access. It also includes new direct defences on the left bank of the River Lee, from the Lee Road in front of the Waterworks extending to Thomas Davis Bridge.

The objective of this measure would be to prevent flooding in the Victoria Cross area and would be relatively uncomplicated. Figure 30 illustrate this measure.

This measure will be considered as part of the emerging options, the final alignment will be subject to how the Curragheen and South Channel defences are addressed.

Figure 30: Direct Defences at Victoria Cross



10.1.5 Area 2: North Channel West

During the assessment of the measures, it was established that direct defences are required in the city centre, Areas 2 to 6. Large sections of the existing walls have gaps or holes in them which are not adequate to contain the design events. Upgrading or new installation of flood defence walls will provide protection to much of the city in both fluvial and tidal events. The section below only details those areas where there are alternative alignments and extents of direct defences to be assessed, namely.

- Fitzgerald Park Measures
- Distillery Fields Measures

Direct defences in the remaining city areas are detailed in relation to the various Options later in this report.

10.1.6 Fitzgerald Park Measures

A number of measures were considered in Fitzgerald Park, taking into account the key infrastructure, including the playground, the mature trees, the museum/café and the bandstand plaza. The measures ranged from fully defending the park and all its infrastructure, to not providing defences and utilizing the park as storage during extreme flood events. They were developed in conjunction with Cork City Council and its landscape architect, following a number of workshops where the technical and aesthetic merits of each measure was discussed.

The following measures in the vicinity of Fitzgerald Park, were considered as described and illustrated below:

- Direct defences along northern park boundary.
- Direct defences through park following existing footpaths.
- Direct defences to north of Mardyke Walk.

10.1.6.1 Measure A: Direct Defences along Northern Park Boundary

This measure would include raising the existing footpath along northern park boundary to defence level (or possibly construct new flood wall, or a combination of both), construction of a flood defence wall along river bank around tennis club and a flood defence embankment through the green area east of the tennis club.

This measure is illustrated in Figure 31.

10.1.6.2 Measure B: Direct Defences through Fitzgerald Park

This measure would include a flood defence wall along Ferry Walk, a defence wall or embankment through Fitzgerald Park with the defence line continuing downstream as per Measure A. It would defend all properties while retaining some storage in Fitzgerald Park.

This would be very disruptive for Fitzgerald Park both during construction and more importantly for its operation, as it would result in dividing the park area. A detailed assessment of the impact on Fitzgerald Park would need to be carried out if this measure is considered further. This measure is illustrated in Figure 31.

The modelling shows that there is a negligible difference in water levels downstream when this measure is applied.

10.1.6.3 Measure C: Direct Defences to North of Mardyke Walk

This measure would generally consist of a defence wall or embankment to the north of Mardyke Walk. It would protect a number of properties on Mardyke Walk. This measure would include the lowest defence heights with possible opportunities to utilise existing walls.

This measure would leave several at-risk properties outside of the defence perimeter. A detailed assessment of the impact on these properties would need to be carried out if this measure is considered further. Access points for the undefended properties would also need to be assessed. This measure is illustrated in Figure 31.

The modelling shows that although there is a reduction in water levels with this measure, the difference in flood level was less than 60mm downstream in the North Channel. On balance, it was considered that the benefits of this measure do not outweigh the potential issues outlined above, and therefore it will not be considered in the options development.

Figure 31: Fitzgerald Park Measures

10.1.7 Distillery Fields Measures

Measures considered in the vicinity of Distillery Fields generally consist of direct flood defences. They are described and illustrated below:

10.1.7.1 Measure A: Direct Defences around Butler Building and Enterprise Centre

This measure allows flooding of the Distillery Fields area and would include a flood defence wall around the Butler Building and Enterprise Centre and at the eastern end of the Distillery Fields. These would tie into higher ground. It would also include non-return valves on surface water outfalls to the Mill Race.

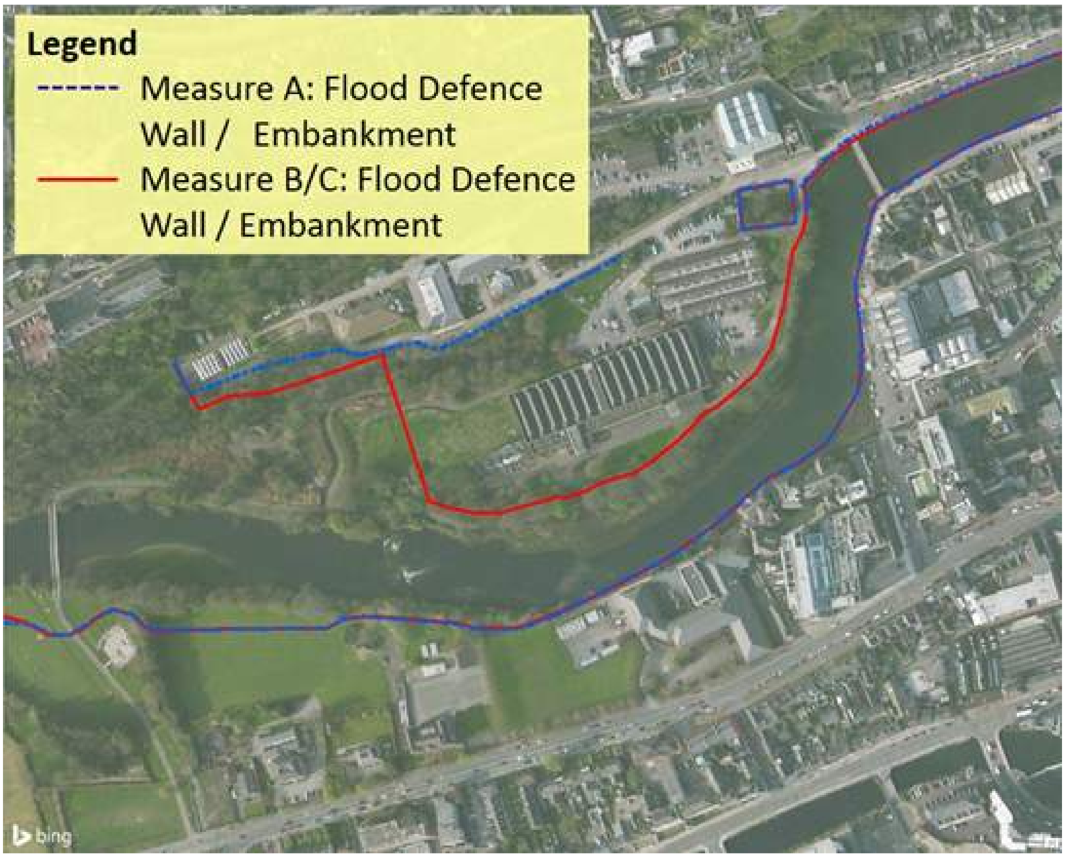
A main drainage interceptor sewer is located along the northern boundary of the Distillery Fields. Manholes along this sewer previously surcharged and overflowed on the site during heavy rain. Non-return valves may be required on all lateral connections as well as sealed manhole covers to prevent this occurrence. The alignment of flood defences would also need to be agreed with the relevant stakeholders. In addition, it is important to note that the western part of the distillery fields is infested with Japanese knotweed.

St. Vincent’s Bridge is located at the eastern end of Distillery Fields and proposed design levels suggest that the bridge will surcharge. A structural assessment would therefore be required if this measure is taken forward. Figure 22 illustrate the potential measures at Distillery Fields.

The Butler Building and Enterprise Centre already have a defence scheme in place. This scheme relies on existing building walls, demountables and non-return valves, however it is not to the scheme design standard.

The benefit of allowing the Distillery Fields to flood, is a reduction in peak water levels of between -10mm and -20mm. It does not have a major impact on water levels and defence heights, therefore this measure will not be brought forward to the options development stage.

Figure 32: Distillery Fields Measures



10.1.7.2 Measure B: Direct Defences Combined with Backfilling of Existing Mill Race

This measure would prevent the floodwaters from entering the Distillery Fields area. A flood defence wall would be installed as illustrated in Figure 32 and would be combined with backfilling of the existing mill race and intercepting all existing surface water connections to the Mill Race.

Many of the design issues outlined with Measure A apply to this measure also.

Following consultation with UCC and the Mercy Hospital, backfilling the existing Mill Race was discounted as it did not meet their masterplan objectives.

10.1.7.3 Measure C: Direct Defences Combined with Isolation of Mill Race

This measure would prevent the floodwaters from entering the Distillery Fields area. A flood defence wall would be installed as illustrated as Measure B in Figure 32 and would be combined with the isolation of the existing Mill Race. This isolation would be achieved using flow control structures to be operated during flood events.

This measure of full protection will be carried forward to the emerging scheme option.

10.1.8 Area 4: North Channel East

During the assessment of the measures, it was established that direct defences are required in Areas 2 to 6. Upgrading or new installation of flood defence walls will provide protection to much of the city in both fluvial and tidal events.

It should be noted that the design case for this area is the tidal event, therefore the direct defences design will not be impacted by the potential South Channel flow management measures.

Two alternative measures were investigated and assessed in the area of Custom House as outlined below:

10.1.9 Custom House Quay Direct Defences

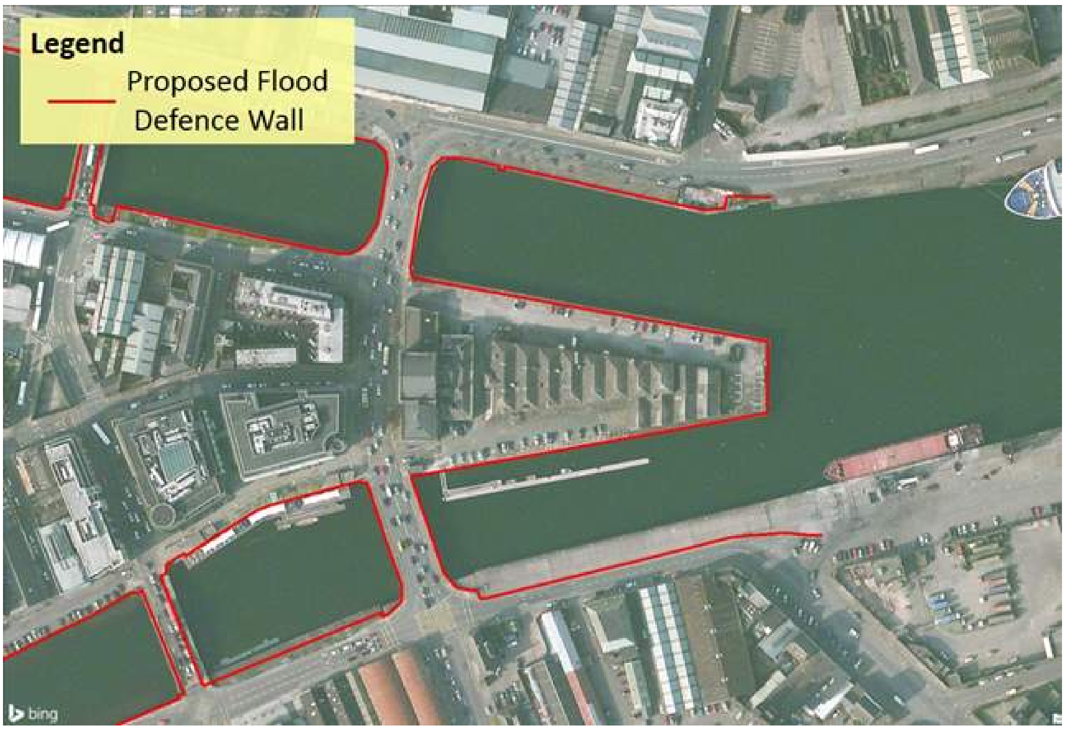
Measures considered in the vicinity of Custom House Quay generally consist of direct flood defences. They include the following and are described and illustrated as follows:

- Direct defences primarily along existing quay walls.
- Direct defences on Custom House Street.

10.1.9.1 Measure A: Direct Defences Primarily Along Existing Quay Walls

This measure would include direct defences along the existing quay walls as shown in Figure 33.

Figure 33: Custom House Quay Direct Defences on existing Quay Walls



This measure will not be carried forward to the options development for a number of reasons. There is a floating pontoon in use on the south quay which would require demountable defences to be implemented during flood events. The south quay wall is in poor condition. The north quay wall is used as a layby berth and any works would disrupt operations. Furthermore the floor level of Custom House is above the defence level and therefore defences are not necessary to protect the property.

10.1.9.2 Measure B: Direct Defences on Custom House Street

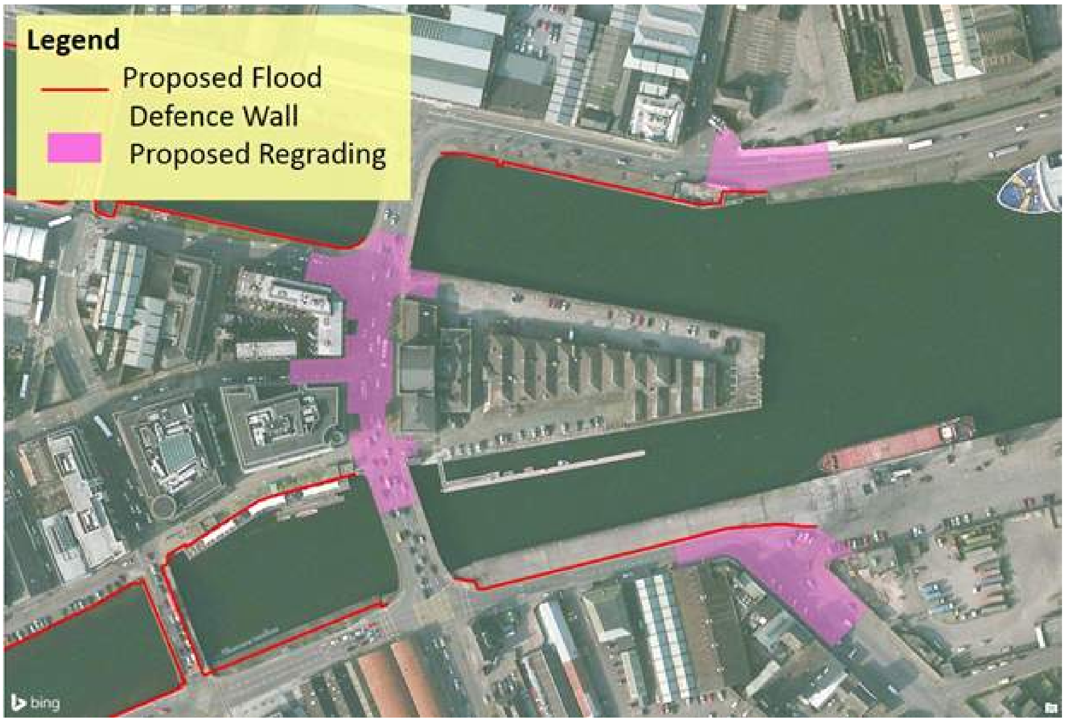
With this measure, the high point of Custom House Street would be raised and used as the flood defence line. This would involve raising the road in combination with service and drainage modifications. The Custom House Quays would not be defended in this measure.

The length of defence required would be less than that of Measure A. The functions of Custom House Quay and the pontoon would not be compromised.

The Custom House and warehouses would be undefended, however the ground floor of Custom House is understood to be well elevated compared to the road level.

This measure is shown in Figure 34.

Figure 34: Custom House Quay Direct Defences on Custom House Street



This measure will be carried forward to the options development as it is the most appropriate for the reasons outlined above.

10.1.10 Area 5: South Channel East

The main measures considered in this area consist of direct flood defences, as apply in all areas of the city centre.

In this area, there are no alternative alignments to be considered. In general, the majority of quay walls will have to be upgraded as part of the flood relief scheme works.

Figure 35 shows the extents of the channel that will require upgrading or the installation of new direct defences.

Figure 35: Tidal Direct Defences

10.1.11 Area 6: South Channel West

The main measures considered in this area consist of direct flood defences, similar to elsewhere in the city centre.

10.1.12 Area 7: Curragheen Direct Defences

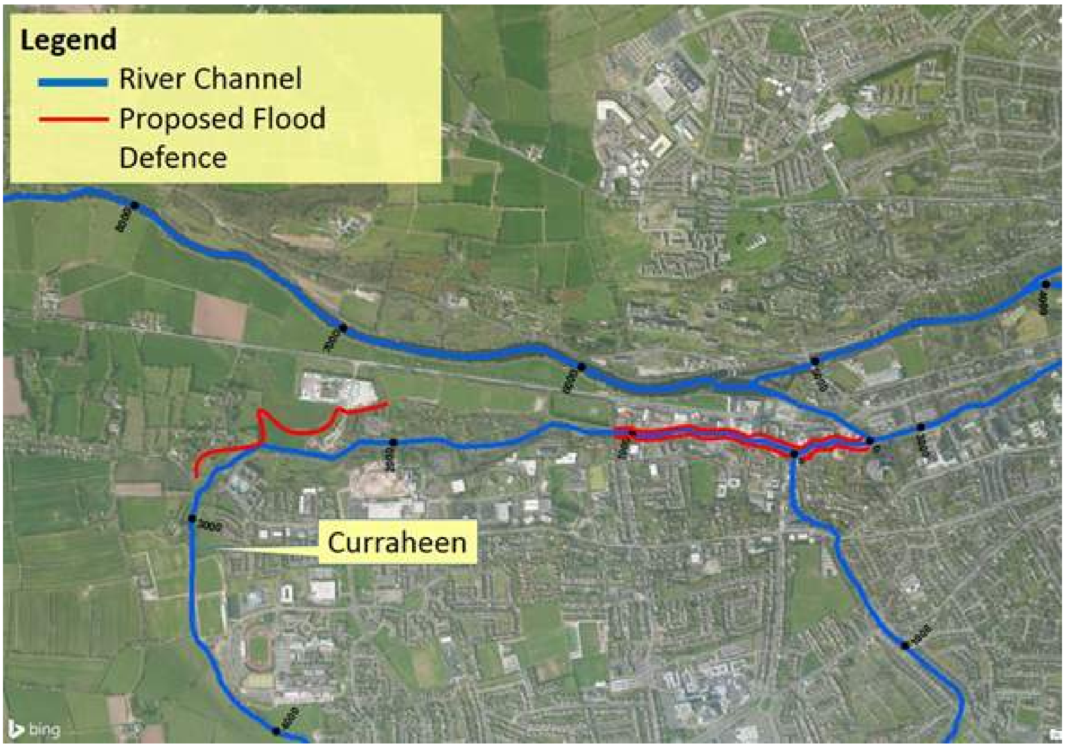
The purpose of this measure is to protect the area around Victoria Cross, from the flood levels driven by backwatering from the South Channel and/or high Curragheen flows.

It includes approximately 1km of raised reinforced concrete extensions to existing channel walls, approximately 300m of new flood defence walls along left bank (at downstream end), new/raised bridge parapets (at 4 reinforced concrete bridges) and non-return valves on all drainage outfalls.

The impact of this measure on Victoria Bridge would also need to be assessed in the Detailed Design stage.

This measure is illustrated in Figure 36.

Figure 36: Curragheen Direct Defences



This measure will be carried forward to the options development stage as required.

10.2 In-channel Flow Regulation

10.2.1 South Channel Flow Management Measures

During development of options, it became clear that containment of the River Lee along the South Channel based on the current split of flow between the north and south channel in high flows results in particularly high structures on the south channel and Curaheen.

The South Channel has a limited capacity to convey flow compared to the North Channel.

Therefore, an alternative measure considered was to regulate the flow entering the south channel to reduce the proportion of flow taken by the south channel and increase the proportion of flow in the North Channel during extreme events.

Any reduction in flow on the South Channel would equate to reduced defence levels along this reach.

The following measures involving the management of flows in the South Channel, considering both tidal and fluvial events, were considered as described and illustrated below:

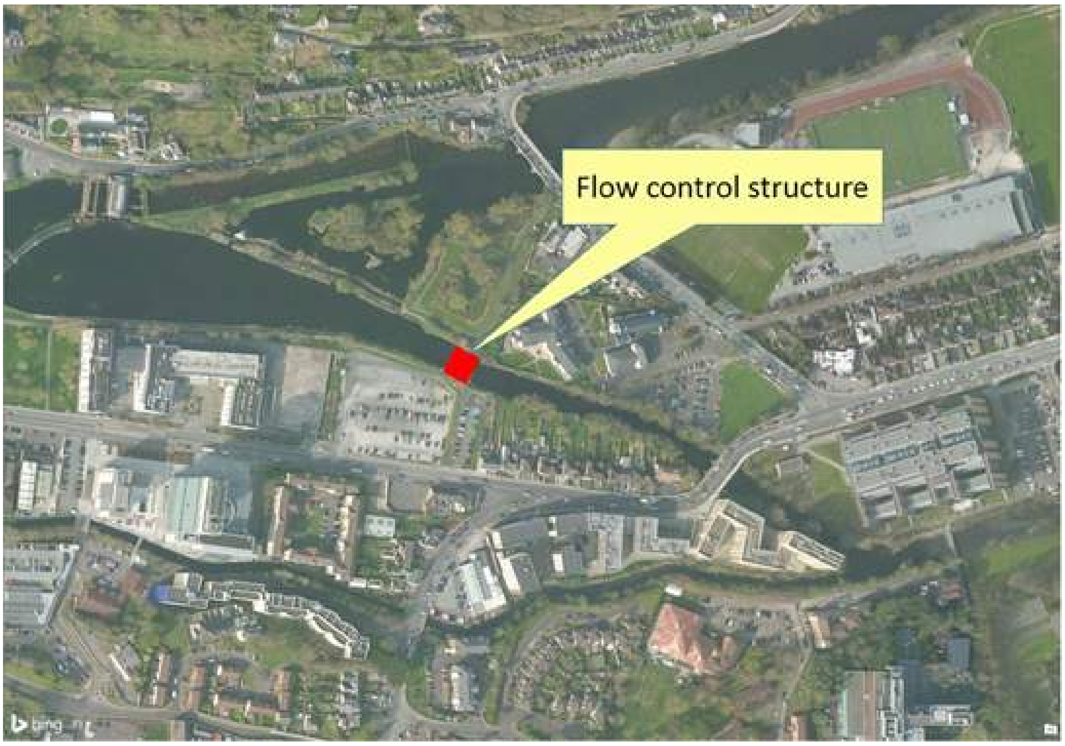
- Flow reduction in South Channel using flow control structure
- Isolation of South Channel
- Flow reduction in South Channel via reduction in the height of the Salmon Weir

10.2.1.1 Flow Reduction in South Channel using Flow Control Structure

The purpose of this measure would be to significantly reduce or prevent flow entering the South Channel from upstream of the River Lee with the installation of a flow control structure which would force greater flow over the Salmon Weir and down the North Channel during a flood event. The structure would be located at the head of the South Channel as shown in Figure 37.

This measure has the potential to significantly reduce the extent of fluvial defences required on the South Channel to the west of the city. Additional assessment would be required to determine the water levels upstream of this measure and the maintenance costs.

Figure 37: Flow Reduction in South Channel using Flow Control Structure



This measure will be carried forward to the options development, as it is a viable approach to controlling the flow into the South Channel, which will be an important aspect to the flood relief scheme.

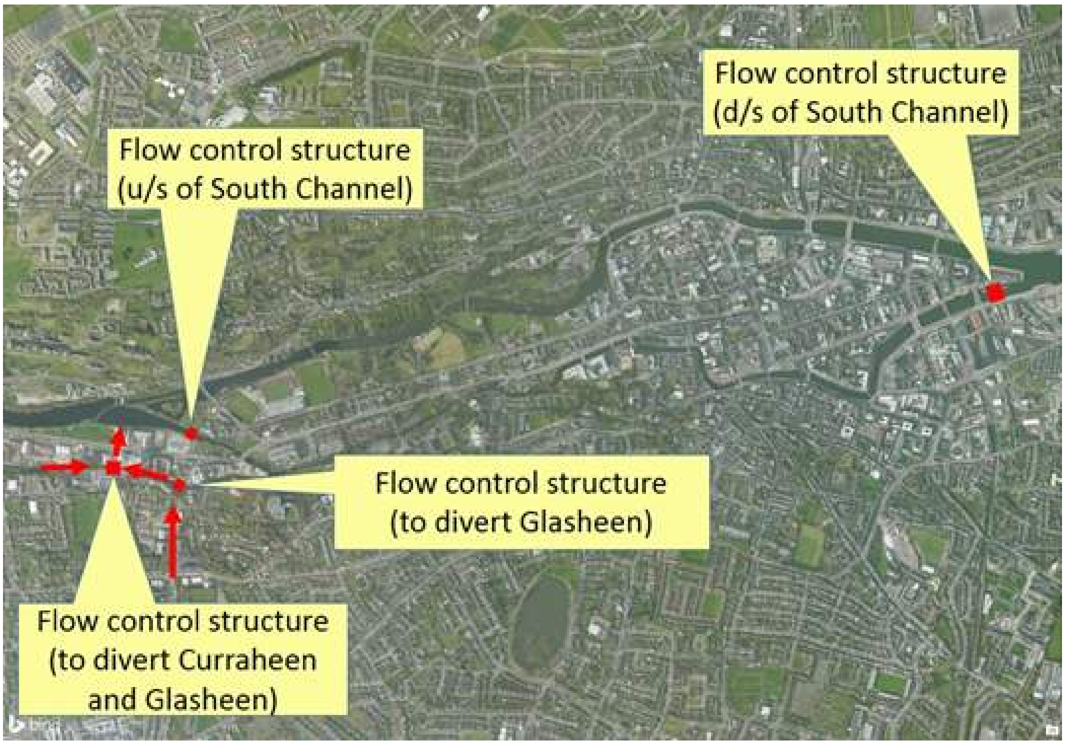
10.2.1.2 Isolation of South Channel

The purpose of this measure would be to prevent flow entering the South Channel during extreme events, both fluvial and tidal, thus removing the requirement for raised defences and quay wall remedial works along the South Channel.

It would involve the construction of a number of flow reduction/isolation structures. The downstream structure would provide a defence against tidally driven events, forming a barrier to the incoming tide and reducing the defence levels at the downstream (eastern) part of the South Channel.

Three flow control structures would be required in the icinity of Victoria Cross to and divert the Curragheen River and Glasheen River and reduce the inflow to the South Channel from the Lee. The diverted Curagheen and Glasheen rivers would need to discharge into the River Lee upstream of Salmon Weir. The measure is illustrated in Figure 38 below.

Figure 38: Isolation of South Channel



A number of issues need to be considered as part of this measure as follows:

There is unlikely to be sufficient capacity in the South Channel to store the waters incoming from the Glasheen River, Curragheen River and the drainage from the city.

Diversion of the Curragheen and Glasheen towards the River Lee by discharging them upstream of the Salmon Weir would be required resulting in increased water levels and greater lengths and heights of defences along the Curaheen and Glasheen. This measure also raises the water levels on the North Channel so the impact of this increased water level will need to be assessed.

Additional assessment would be required to determine the potential for groundwater ingress into the isolated South Channel and consideration of the impact on Port of Cork at Custom House Quay and Albert Quay East would also need to be considered.

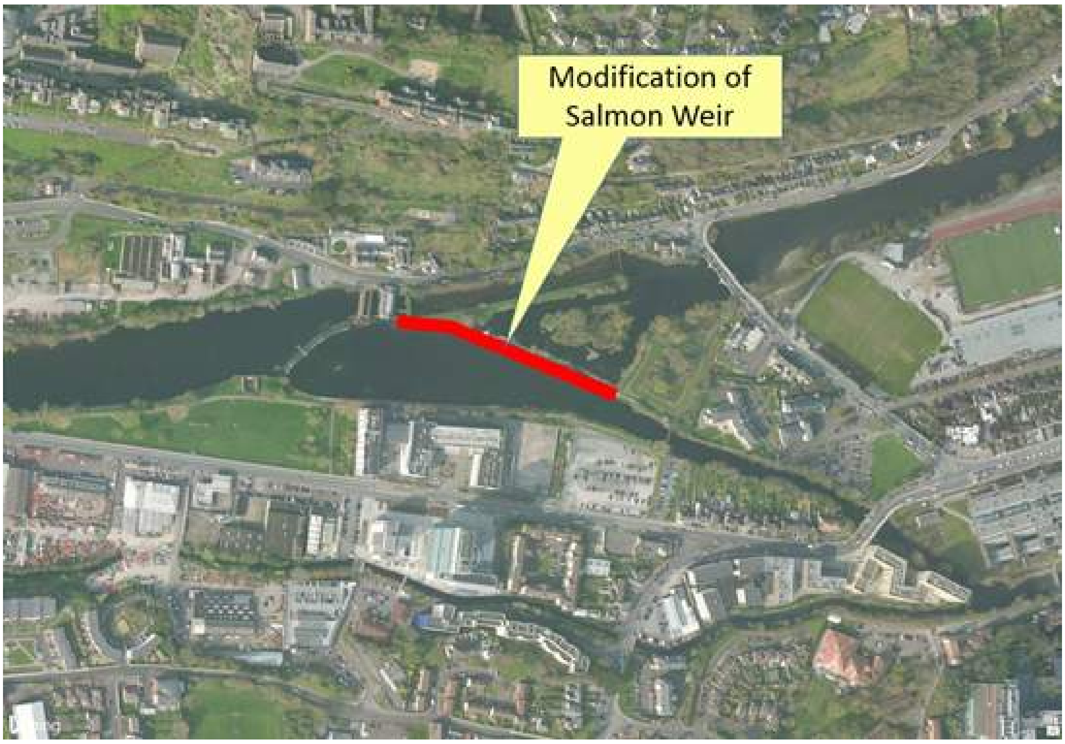
This measure will be carried forward to the options development, as it demonstrates the benefits of controlling the flow into the South Channel, and its importance to the flood relief scheme.

10.2.1.3 Flow Reduction in South Channel via reduction in the height of Salmon Weir

This measure proposes modifying the Salmon Weir to allow more flow over the crest in the event of a flood.

This purpose of the measure is to increase the flow in the North Channel and to potentially reduce the extent of fluvial defences required on the South Channel to the west of the city. It would be achieved by reducing the height of the Salmon Weir and possibly including a moveable section to further lower the weir during a flood. Figure 39 illustrates this measure.

Figure 39: Flow Reduction in South Channel via Reduction in the Height of the Salmon Weir



By lowering the weir, a marginal decrease in water levels on the South Channel is achieved at higher tides. However this measure would also impact during low flows and would have a negative environmental impact. Therefore alterations to the Salmon Weir will not form part of an emerging flood relief option.

10.2.2 Other Channel Flow Control Measures

The following measures consider flow control of the Curragheen and/or Glasheen Rivers. In general the purpose of these measures is to reduce the peak flow within the South Channel.

10.2.3 Curragheen Diversion Culvert

The purpose of this measure would be to reduce the peak flow in the downstream section of the Curragheen River and therefore the South Channel. This measure involves building a diversion culvert and a dynamic control structure which can control and divert the Curragheen River flow in the event of a flood.

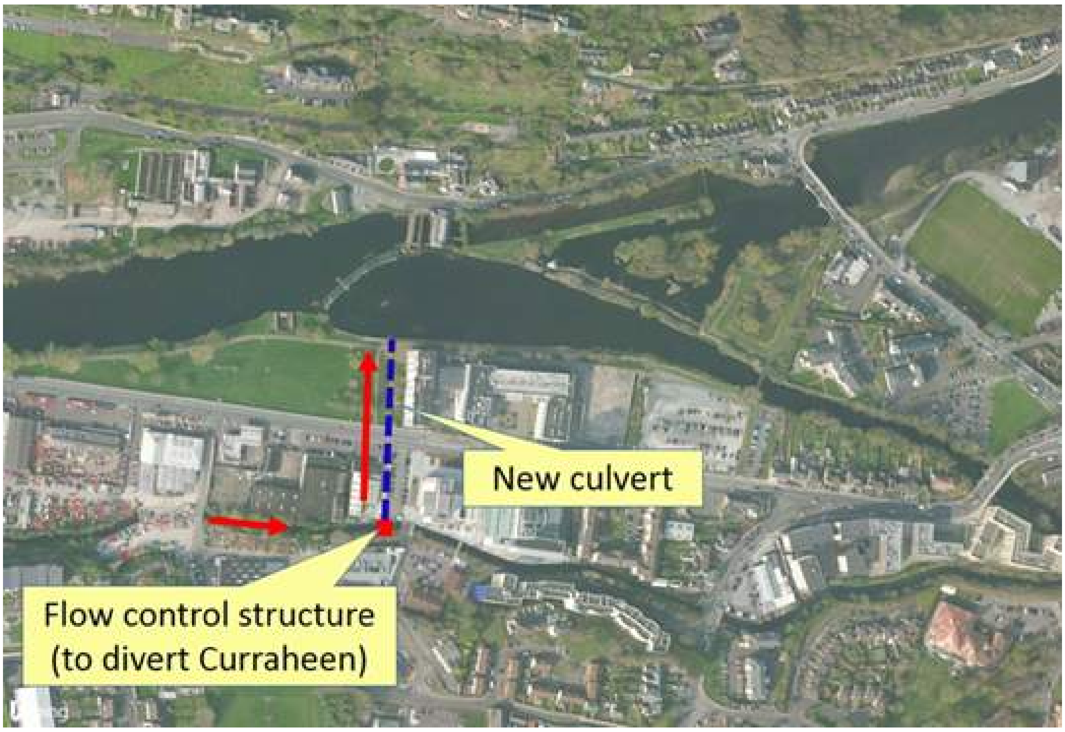
This measure is illustrated in Figure 40 below.

It would include the construction of a new reinforced concrete structure with inlet to a new culvert, an orifice to allow limited (if any) flow down the existing channel. The diversion channel would enter the River Lee downstream of the Waterworks weir. Under 'normal' flows, water would follow its current route into the South Channel.

This measure would reduce the extent/height of works downstream on the Curragheen and the South Channel. In addition to the connection downstream of the Waterworks Weir, lowering of the Salmon Weir may also be required to mitigate backwatering of the culvert. It may also be necessary to prevent crossflow from the River Lee at Inchigaggin so as not to increase risk to the properties at this location, refer to measures in Section 10.1.3.

This measure could be considered to support the South Channel isolation measure.

Figure 40: Curragheen Diversion Culvert Tying in Downstream of Waterworks Weir



10.2.3.1 Temporary Diversion of both Curragheen and Glasheen Rivers

The purpose of this measure would be to facilitate isolation of the South Channel, which would reduce the flow in the South Channel, therefore reducing requirement for defences within the South Channel.

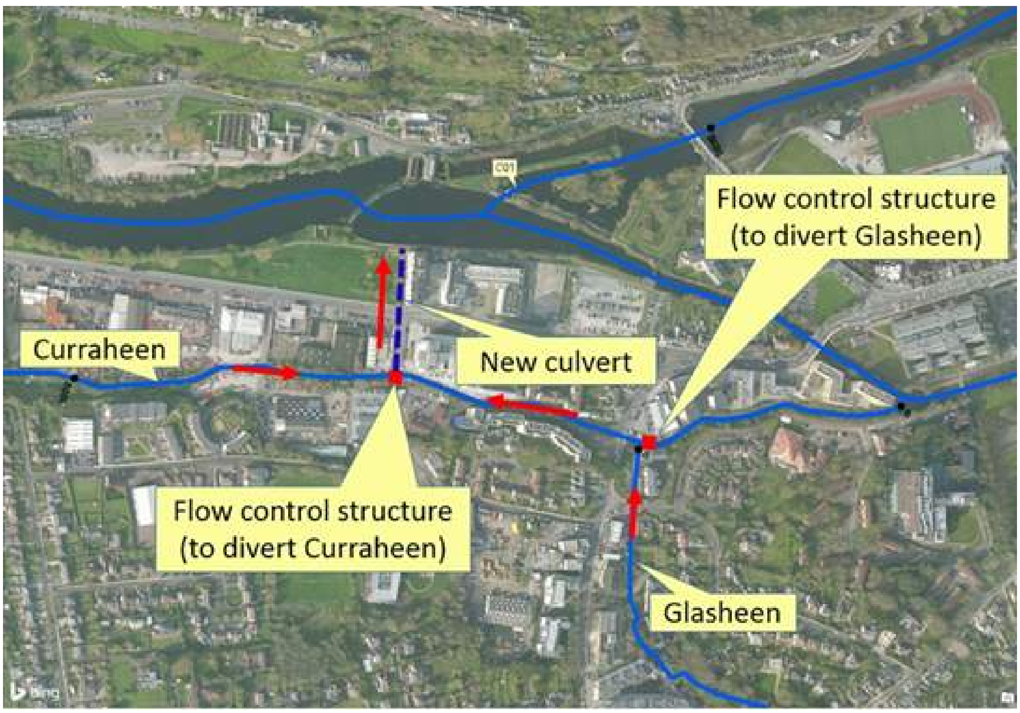
A permanent arrangement was considered, including backfilling a length of the Curragheen channel downstream of confluence with Glasheen, re-grading of existing channels and a culvert to allow the Glasheen to flow west and construct new diversion structure and culvert to allow the Curragheen and Glasheen to discharge to the River Lee. However a permanent diversion would starve the South Channel of flow year round which would have a very significant negative environmental impact and permanently elevate normal water levels on the Curaheen and Glasheen, potentially significantly altering drainage systems in the Victoria Cross Area.

Therefore a temporary solution, only to be implemented during flood events, would be preferred. This would consist of a flow control structure at the confluence between the Curragheen and the Glasheen, and new diversion structure and culvert to allow the Curragheen and Glasheen to discharge to the River Lee downstream of the Waterworks Weir. Figure 41 illustrates this measure.

This measure would result in positive effects on the South Channel with a reduction in water levels in the western reach. However, there would be a significant increase in water levels upstream of the Curragheen.

As with other measures, a risk assessment would need to be carried out to ascertain whether there would be an increased risk of flooding to properties upstream of this measure.

Figure 41: Diversion of Curragheen and Glasheen Rivers



The measure will be carried forward to the options development stage as a supporting measure to facilitate the isolation of the South Channel.

10.2.3.2 Temporary Diversion of Curragheen River Only

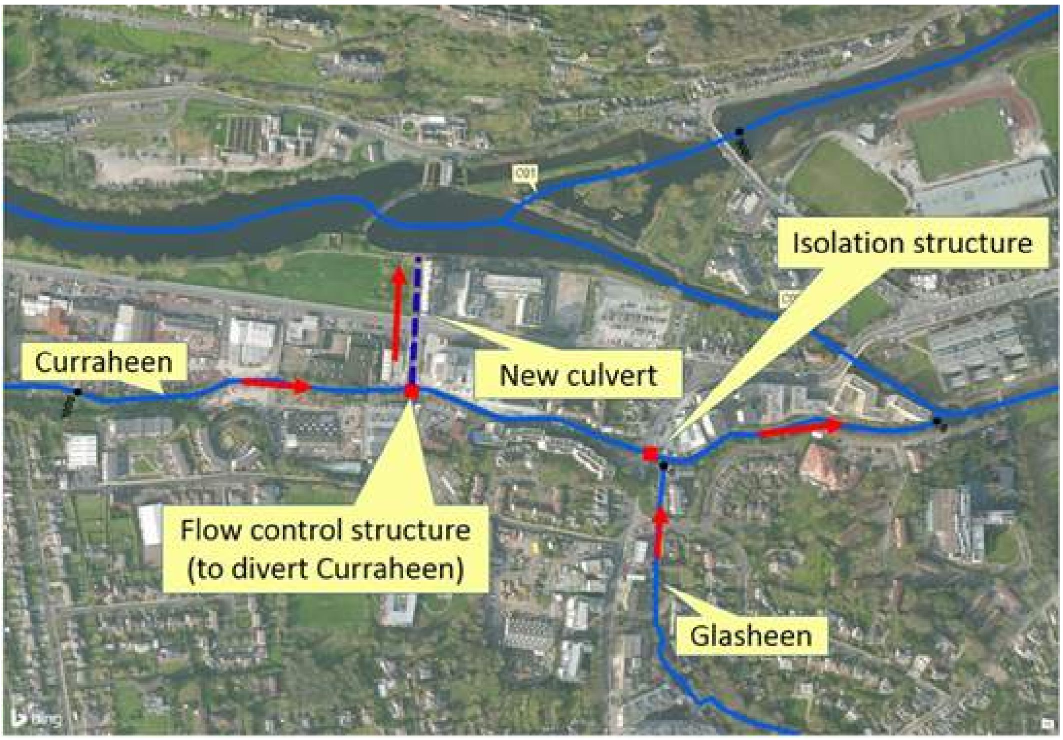
This measure is similar to the temporary diversion outlined above, but only diverting the Curagheen and continuing to allow the Glasheen to follow its existing course as illustrated in Figure 42.

The purpose of this measure would be to minimise direct defences along the Curragheen River and reduce the peak flow in the South Channel.

While this measure would have benefits, it would also pose some problems. The storage in the south channel is unlikely to be sufficient if there was to be a large Glasheen event.

As with other Curragheen measures, a risk assessment would need to be carried out to ascertain whether properties upstream at Inchigaggin would be at risk from flooding as a result of this measure.

Figure 42: Isolation of Curragheen River



This measure would give rise to a reduction in water levels in the South Channel.

10.3 Local Conveyance Improvements

10.3.1 Conveyance Improvements near Inniscarra Bridge

To assist in the reduction of the levels of the direct defences at Inniscarra, various conveyance improvements were evaluated. These measures could potentially reduce the water level upstream and are described in further detail below.

10.3.1.1 Flood Relief Channels Across the floodplain

This measure considers flood relief channels across the flood plain as illustrated in Figure 33. The purpose of the measure is to improve conveyance around the river bend.

It had the effect of increasing levels upstream of Inniscarra Bridge.

The increase in water levels meant floodwaters were slightly attenuated before flowing through Inniscarra Bridge. This measure proves to some extent that the conveyance through Inniscarra Bridge is the critical problem. This measure is not carried forward to the options development stage.

10.3.1.2 New Flood Relief Culverts in the Floodplain under Inniscarra Bridge

This measure considers construction of a new flood relief culverts at Inniscarra Bridge. The purpose of the measure is to improve conveyance under the bridge.

This measure only results in a marginal decrease in the water levels upstream at Inniscarra, and it is therefore not carried forward to the options development stage.

10.3.1.3 Re-grade the Floodplain and Allow More Flow enter Ballincollig Canal

This measure considers re-grading of the floodplain to the south of the river to allow more flow to enter the Ballincollig Canal, as illustrated in Figure 43.

The purpose of the measure is to improve conveyance.

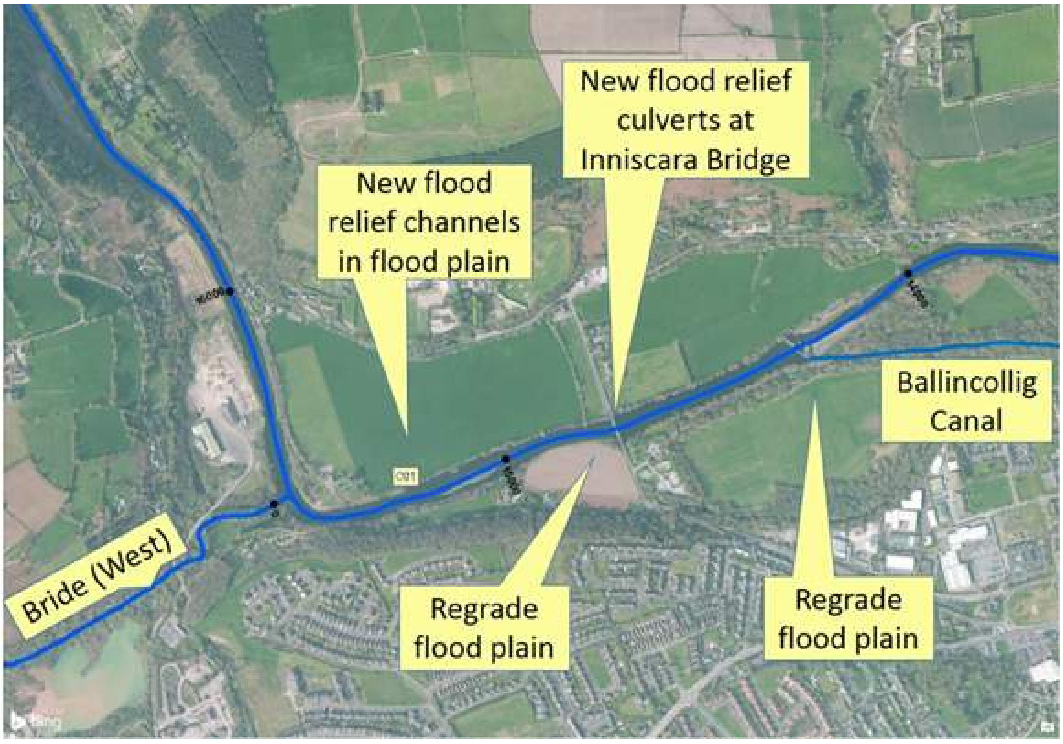
However it was assessed that there will only be a marginal decrease in flood levels, which does not negate the requirement for defences upstream. Therefore it is not carried forward to the options development stage.

10.3.1.4 Regrade and Improve the Approach to Inniscarra Bridge

This measure considers re-grading of the approach to Inniscarra Bridge. The purpose is to improve conveyance under the bridge.

However it was assessed that there will only be a marginal decrease in flood levels, which does not negate the requirement for defences upstream. Therefore it is not carried forward to the options development stage.

Figure 43: Conveyance Improvement Measures



10.3.1.5 Channel Widening

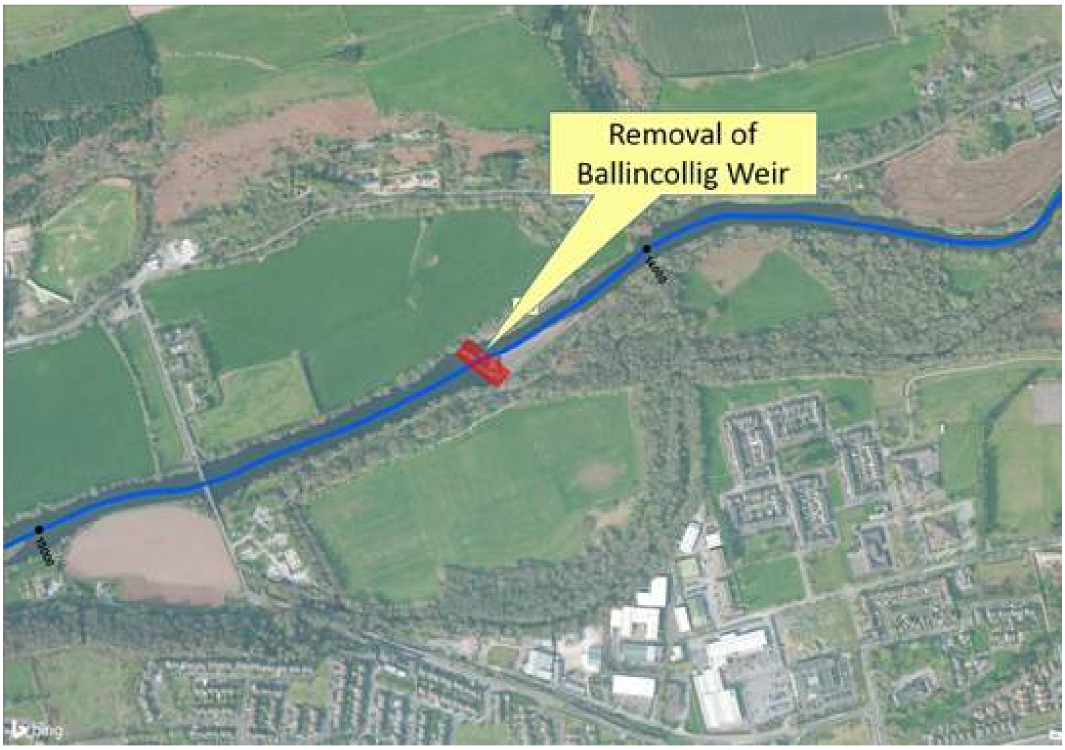
Channel widening as a measure was considered at Inniscarra Bridge. It is not considered a technical or economically viable measure in this scheme and is not brought forward to the options development stage.

10.3.1.6 Removal of weir at Ballincollig

This measure involves the removal of the in-line weir at Ballincollig. The purpose of the measure is to improve conveyance in the area.

While there is a benefit of removing the weir, with some reduction in water levels locally around the weir and upstream of Inniscarra Bridge, it does not impact a critical area and it does not significantly reduce the need for direct defences downstream. Therefore it will not be brought forward to the options development stage.

Figure 44: Removal of Ballincollig Weir



10.3.2 Conveyance Improvements at Waterworks Area

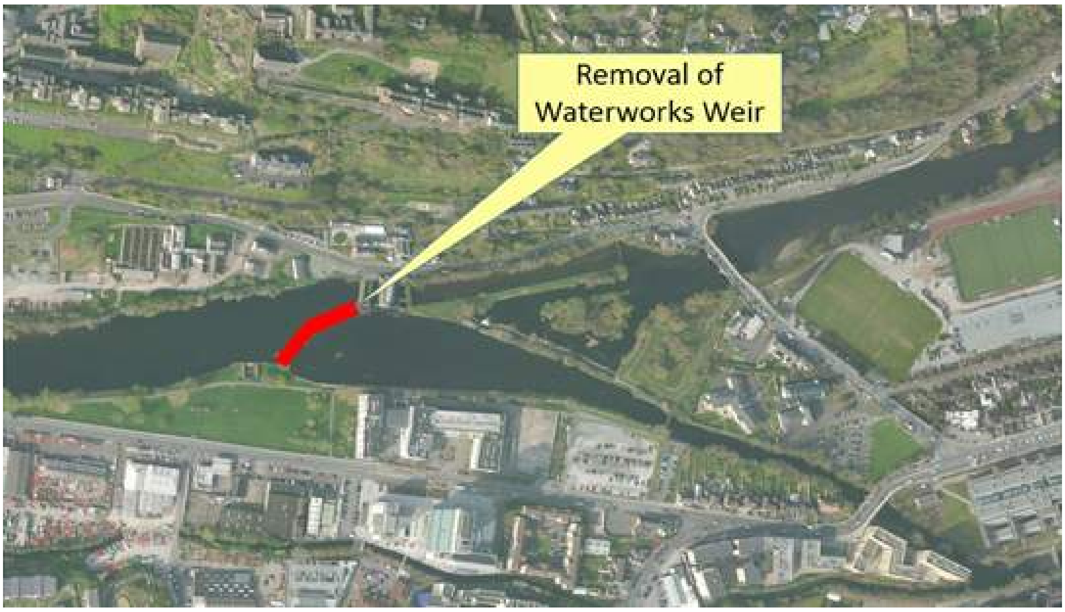
10.3.2.1 Waterworks Weir

This measure involves the removal of the Waterworks Weir. The purpose of the measure is to improve conveyance of the flow in the channel.

However it only results in minor water level reductions locally when considered in conjunction with high tides and does not have a significant impact on the defences required in the design case.

Furthermore it may impact water supply to the Waterworks due to the location of the intake structure. It is also important in a heritage context. Therefore it will not be brought forward to the options development stage.

Figure 45: Removal of Waterworks Weir



10.3.2.2 Height Reduction of Salmon Weir

This measure is outlined above in relation to a flow control measure of the South Channel. As described, it will not be brought forward to the options development stage.

10.4 Localised Surface Water Pumps

Pumping as stand-alone measure is not a technical or economically viable measure for this scheme.

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.

11 Freeboard Analysis

11.1 Introduction

Freeboard is a factor of safety usually expressed in height above a flood level for purposes of flood risk management. Freeboard is typically applied to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood, such as uncertainty of the effect of bridges, hydrological uncertainty, uncertainty in model roughness etc.

The OPW traditionally applied a freeboard of 0.3m for hard defences and 0.5m for soft defences, and whilst this is appropriate in many situations, there are instances where a higher freeboard should be allowed.

11.2 Freeboard for Hydrological/Hydraulic Uncertainty

A specific freeboard allowance for hydrological/hydraulic uncertainty has been calculated for this scheme as follows:

$$F_B = \sqrt{\sum A_1{}^2 + A_2{}^2 + A_3{}^2 + A_4{}^2 + A_5{}^2}$$

Where:

FB is the Freeboard Allowance in meters (for hydrological/hydraulic uncertainty);

A1 to A5 is the uncertainty in water level estimates for each input type. It was decided to take the average difference through the given reach and apply the one standard deviation value to the average. This way the value chosen will consider a range of values concentrated around the average and excludes any outliers that may be unduly influencing the freeboard.

Table 6 presents the input parameters tested with a brief description.

Table 6: Freeboard Hydrologic/Hydraulic Parameter Tested

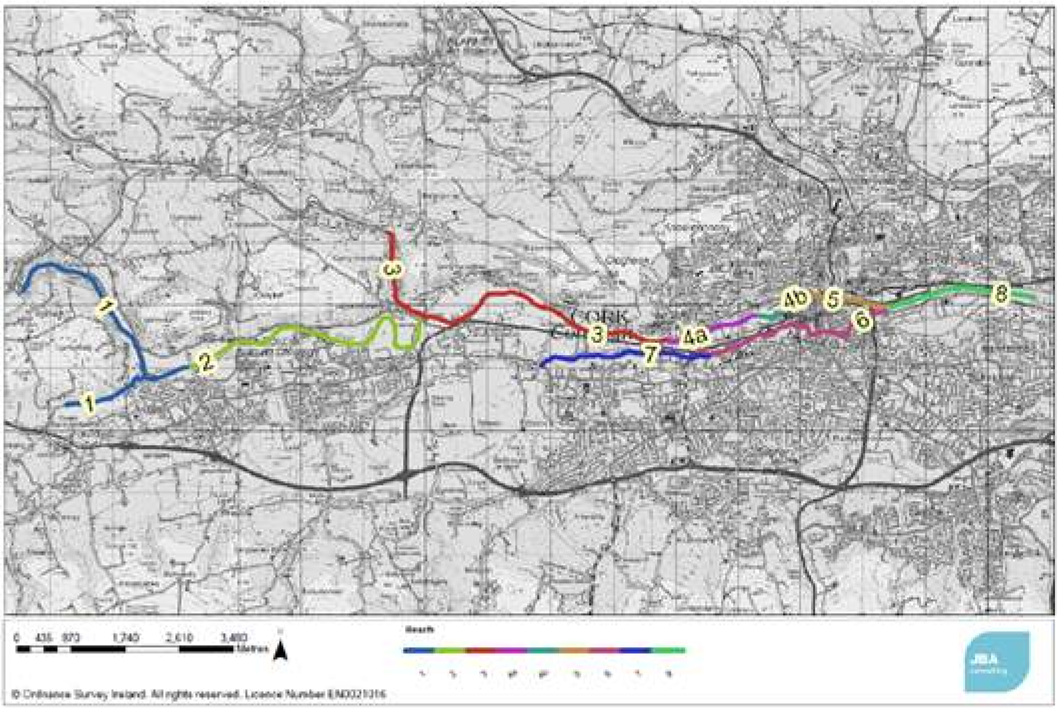
Parameter	Type	Description
A1	Weir Coefficient	The in-line fluvial weirs are tested by reducing the coefficients of discharge.
A2	Roughness	The model’s manning's n value indicating general roughness was increased to cover the uncertainty of the initial estimation.
A3	Coefficient of Velocity	The coefficients of velocity within the orifice equation on Christy Ring Bridge are conservatively set back to 1.0. Because Christy Ring lies outside the physical model test, there is an uncertainty attributed to altering the coefficient value.

Parameter	Type	Description
A4	Overtopping Weirs	The overtopping weirs on St. Vincent's Bridge and Shandon Bridge were increased by 0.5m. St.Vincent's Bridge and Shandon Bridge allow for overtopping on the parapet it is reasonable to assume that should blockage occur, the water level would increase.
A5	Peak Flow	The uncertainty in the derived peak flow was developed and this allows an assessment of sensitivity flow on the water levels. A 10% increase in flow to the upper catchment and reservoirs was applied.

The tidal element of the freeboard is dictated by the uncertainty in deriving the peak sea level for the design tidal event. This was assessed during the Lee CFRAM and based on the uncertainty analysis carried out in that study, the average value of uncertainty for the prediction is estimated to be 0.147m. A further 50mm is added to this value to allow for the constrained tidal boundary and variations in wind which may influence the uncertainty.

Figure 46 shows the breakdown of the reaches in terms of sections and the locations throughout the Lower Lee catchment.

Figure 46: Overview of Freeboard Reaches



Results show that the freeboard in some sections is higher than the 0.3m typically applied by the OPW. This is because of the complex nature of the Lower Lee system.

The freeboard associated with the derived tidal extreme sea levels is 0.20m. This is applied in addition to the tidal hydrologic/hydraulic freeboard tests. Therefore, the resulting freeboard is shown in Table 7 and it ranges from 0.20m to 0.50m.

These values do not account for construction allowances or super-elevation, which are described in the section below.

Table 7: Summary of Freeboard Results

Reach	Description	Fluvial hydrologic/ hydraulic freeboard (m)	Tidal peak sea level uncertainty + Tidal hydrologic/ hydraulic freeboard (m)
1	Inniscarra to Inniscarra Bridge	0.34	n/a
2	Inniscarra Bridge to Leemount	0.25	n/a
3	Leemount to Waterworks Weir	0.28	n/a
4a	Waterworks Weir to Mardyke Bridge	0.44	0.27**
4b	Mardyke Bridge Griffith Bridge	0.50	0.30
5	Griffith Bridge to South Channel Confluence	0.16	0.24**
6	South Channel	0.00*	0.26**
7	Curragheen River	0.40	n/a

*Note: This is for the preferred option where the flow control structure restricts flow from the Lee. It should be noted that in Option 3 the fluvial freeboard for Reach 6 is 0.4m

** Please note that a minimum tidal hydrology/hydraulic freeboard of 300mm has been adopted

11.3 Physical Processes Freeboard

The physical processes freeboard is the allowance for construction uncertainty and settlement. For this scheme, this has been set at 0.1m for hard defences, and 0.3m for soft defences.

11.4 Super-Elevation Freeboard

Super-elevation is the effective increase in water levels as the river flows around a bend. There is an increase in the water level at the outer bank and a decrease in water level on the inner bank due to the centrifugal force that is exerted on the river body.

A physical model was established for part of this scheme and testing showed super-elevation may be critical in the reach from Mardyke Bridge to Christy Ring Bridge. Four bends were considered for analysis, see Figure 47 and the findings are shown in Table 8 below.

Super-elevation was not accounted for anywhere else in the model because it was not deemed to be critical and is considered to be addressed by the general hydrological/hydraulic freeboard.

Figure 47: Super-Elevation Reaches

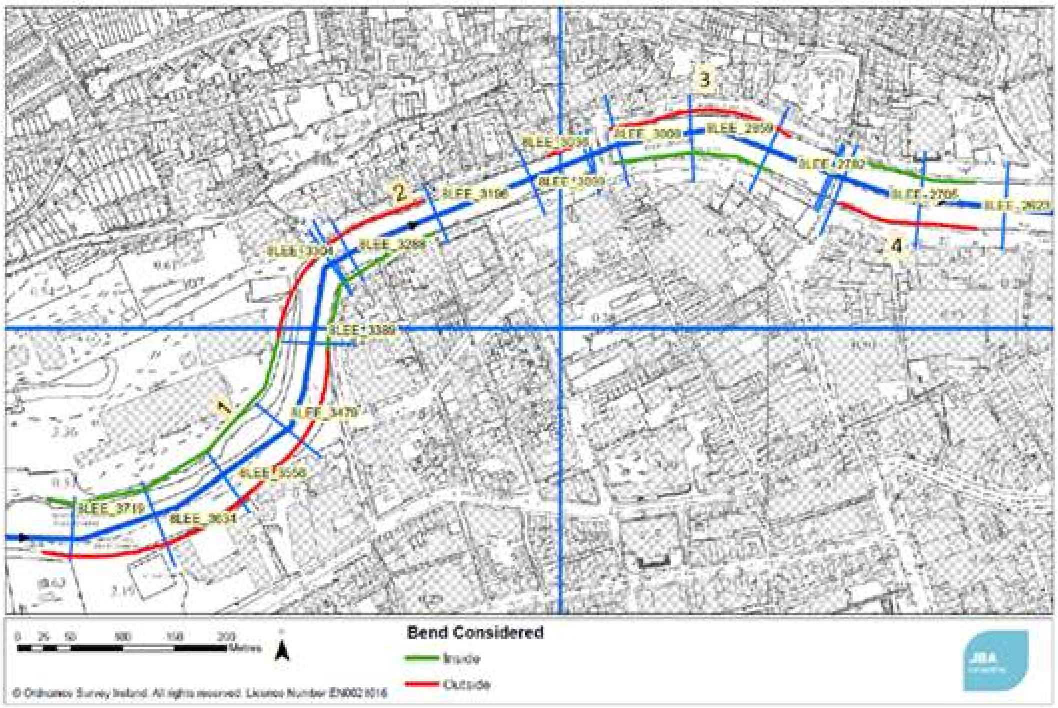


Table 8: Reaches Affected by Super-Elevation

Reach	Description	Maximum Super-elevation in reach*
1	Mardyke Bridge to Grenville Place – Right Bank	0.1m
2	Distillery Fields to North Mall Quay – Left Bank	0.16m
3	Griffith Bridge to Pope's Quay – Left Bank	0.25m
4	Shandon Bridge to Christy Ring Bridge – Right Bank	0.14m

*It should be noted that this super-elevation applies to the fluvially dominated design case. Superelevation effects are more muted in the tidally dominated case.

11.5 Design Defence Level

The design defence level is calculated using the modelled peak water level, the hydrological/hydraulic freeboard, the relevant physical processes freeboard and the super-elevation freeboard. The design of the defences is driven by the greater of the fluvial or tidal event in that area.

Table 9: Calculation of Design Defence Levels

Operation	Fluvial	Tidal	Comment
	Peak Water level for fluvially dominated design case	Peak Water level for tidally dominated design case	Water level from ISIS modelling at node for the Fluvial and Tidal events using the emerging flood relief option measures and alignments.

Operation	Fluvial	Tidal	Comment
+	Fluvial Hydrologic/ hydraulic Freeboard	Tidal Hydrologic/ hydraulic freeboard including peak sea level uncertainty freeboard (0.300m)	Freeboard for given reach within that node lies for Fluvial and Tidal events. The tidal freeboard will be the greater of the hydrologic/ hydraulic freeboard or the peak sea level uncertainty.
+	Fluvial Super-elevation freeboard	Tidal Super-elevation freeboard	This is the super-elevation allowance if it is to be considered at the node in question.
+	Relevant Physical processes freeboard		
=	Design Defence Level (fluvial)	Design Defence Level (Tidal)	Used to assess the dominating mechanism driving the defence height i.e. the greater of the tidal and fluvial events at that node.
=	Total design defence height**		Final total design height to which a defence at the given node will be constructed to. (higher of fluvial or tidal case)

** Note that these are the levels that the scheme defences will initially be constructed to. Defences will then be maintained to a minimum of these levels less the freeboard for physical processes (if settlement/consolidation does occur). The higher level is stated on the Exhibition Documentation.

12 Development of Flood Relief Options

12.1 Introduction

Measures which are progressed through the screening stage are combined to create potential options. Most measures, while providing some reductions in flood risk, will not manage the flood risk entirely by themselves. Measures are therefore required to be combined into options so that they will manage the flood risk and achieve the objectives set by the study.

The design standard for this study is the 1% AEP event for fluvial flood risk and/or the 0.5% AEP event for coastal flood risk. The option achieving the design standard must also have provision for adaptability to future scenarios and climate change conditions.

12.2 Selection of Options

Following investigation of the various measures, a number of deductions can be made from the results which inform the emerging preferred flood relief options.

12.2.1 Prerequisite Measures

During the hydraulic modelling and the assessment of measures (Section 4) it became clear that unless potential attenuating benefits of the Inniscarra and Carrigadrohid dams are utilised, design flows at Cork City would be in the order of $860m^3/s$. Such peak design flows would require extensive replacement of bridge structures in combination with very high walls, which would render the solution unacceptable on a number of grounds including economic, environmental and social.

Therefore, it became clear that the implementation of optimised operating rules of the Inniscarra and Carrigadrohid dams in combination with a suitable flood forecasting system and upland washlands are prerequisite measures to the development of a sustainable solution for Cork City. As a result, these prerequisite measures have been taken as included in all options.

12.2.2 Area 1

In Area 1, there is only one option considered. The protection of properties at Inniscarra, Ballincollig and Inchigaggin is achieved by direct defences. These will mainly consist of embankments, with some isolated short lengths of defence walls. The prevention of flow across the N22 at Inchigaggin will also form part of the emerging preferred scheme as there are benefits to the Curragheen River and consequently the South Channel.

12.2.3 Areas 2-6

Within Areas 2, 3, 4, 5 and 6, direct defences will protect all areas in Cork City including Fitzgerald Park, Distillery Fields, Gillabbey Weir area and Custom House Street. South Channel flow management measures outlined in some options benefit some areas and the extent of the defences required will depend on whether flow management measures for the South Channel are implemented within the scheme. There are a number of options to be assessed accordingly.

12.2.4 Area 7

In Area 7, there are a number of options to be considered for the Curragheen and Glasheen rivers, including diversions and/or direct defences. The requirements are also dependent on measures implemented downstream on the South Channel.

12.2.5 Areas 8 & 9

In Area 8, North Docklands, there are no properties at risk and future development should manage flood risk through planning and design.

Most of Area 9, South Docklands, is part of Port of Cork and is operational as working quays. The majority of flooding of south docklands occur via a low point on Victoria Road. These route will be defended by a combination of road re-grading and defence walls.

As the line of the warehouse fronting the south quays is generally at or above the 1 in 200 year tide level, and as this is a discrete flood cell, it has been decided not to proceed with defences in this area, as such defences would be predominantly for the purposes of freeboard only and would severely impact the operational functionality of the working quays in the short term.

Flood risk in this area will ultimately be managed through planning policy and design as part of the future redevelopment of docklands.

12.2.6 Summary

In summary the options considered are as follows:

- **'Do-Minimum'** retained for comparison (see Section 5.1)
- **Prerequisite Measures for all options** (see Sections 6 to 8)
    - Optimised Dam Operating Procedures;
    - Flood Forecasting System and Early Warning Service; and
    - Designated Washlands
- **Areas 1**
    - Direct Defences (only option considered)
- **Areas 2, 3, 4, 5, 6 & 7**
    - Flow Reduction in South Channel and Direct Defences

- Isolation of South Channel and Direct Defences
- Direct Defences only

- **Areas 8 & 9**
    - No defences considered

The constituent elements of Options 1 to 3 is tabulated in Table 10 and Table 11 below.

Table 10: Options and Measures for Area 1

	Option	Area 1A	Area 1B	Area 1C	Area 1D	Area 1E
		Inniscarra	**Ballincollig**	**Carrigrohane Rd**	**Kingsley Area**	**Lee Rd**
1	**Flow reduction in South Channel and Direct Defences**	Direct defences	Direct defences	Direct defences	Direct defences Flow control structure	Direct defences
2	**Isolation of South Channel and Direct Defences**	Direct defences (Same as Option 1)	Direct defences (Same as Option 1)	Direct defences (Same as Option 1)	Direct defences (Same as Option 1) Flow control structure	Direct defences (Same as Option 1)
3	**Direct defences only**	Direct defences (Same as Option 1)	Direct defences (Same as Option 1)	Direct defences (Same as Option 1)	Direct defences (lesser height and extent than Option 1)	Direct defences (Same as Option 1)

Table 11: Options and Measures for Areas 4 to 8

	Option	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
		North Channel West	**River Kiln**	**North Channel East**	**South Channel East**	**South Channel West**	**Curragheen and Glasheen Rivers**
1	**Flow reduction of South Channel and Direct Defences**	Direct defences	Direct defences	Direct defences	Direct defences Flow control structure	Direct defences	No direct defences
2	**Isolation of South Channel and Direct Defences**	Direct defences (greater height and extent than Option 1)	Direct defences (Same as Option 1)	Direct defences (approx. same as Option 1)	No direct defences Flow control structure	No direct defences Flow control structure	Diversion of rivers required Direct defences
3	**Direct defences only**	Direct defences (lesser height and extent than Option 1)	Direct defences (Same as Option 1)	Direct defences (approx. same as Option 1)	Direct defences (greater height and extent than Option 1)	Direct defences (greater height and extent than Option 1)	Direct defences (lesser height and extent than Option 2)

12.3 Option 1 – Flow Reduction in South Channel and Direct Defences

As with all three options, there are a number of prerequisite measures that must be implemented, including Revised Dam Operating Procedures, Flood Forecasting System and Early Warning Service, and designation of Upland Washlands.

In Area 1, west of the Waterworks Weir, only one measure - direct defences - is considered for all three options. The alignment is illustrated in Figure 48.

This differentiator in this option is the inclusion of a flow control structure proposed to be located at the head of the South Channel of the River Lee, downstream of the Salmon Weir. The proposed structure will be closed (or partially closed) when the River Lee is in flood to prevent (or reduce) flow entering the South Channel and divert a greater proportion of the flow to the North Channel which has greater capacity.

By reducing the flow to the South Channel, more flow is diverted to the North Channel and there is a resulting increase in water levels in this reach of between +0.1m and +0.4m in the western reach in comparison to Option 3 where no south channel flow management measures are included. However there is little impact at the eastern end of the North Channel where defence levels are tidally driven.

Conversely by reducing the flow to the South Channel, water levels are greatly reduced from between -0.1m and -0.8m from Eamon De Valera Bridge all the way to Western Rd. This reduction on the South Channel simultaneously aids the Curragheen. The lower water level at the confluence results in lower water levels upstream on the Curragheen River from between -0.5m and -1.5m in comparison to Option 3 where no south channel flow management measures are in place.

Therefore in this option, there is no requirement for construction of new high and visually intrusive defences within the Curragheen (Area 7). It is also not required to divert the Curragheen or Glasheen River during flood events as the South Channel has sufficient capacity for these flows once the flow control structure is in operation.

The reduction of flow to the South Channel is beneficial for Areas 5 and 6 (South Channel West and East), reducing the extent of defences required in the South Channel in comparison to Option 3 with no south channel flow management in place.

This option results in the requirement of slightly higher flood defences in the North Channel West, Area 2, due to the increase in water levels in the western reach. The defences required within Area 4, North Channel East, are similar for all three options as this reach is tidally dominated.

The alignment of the defences within the city centre is illustrated in Figure 49.

Full detailed of the proposed defences associated with Option 1 are included in Table 12 below.

Figure 48: Option 1 – Flow Reduction in South Channel and Direct Defences – West of City

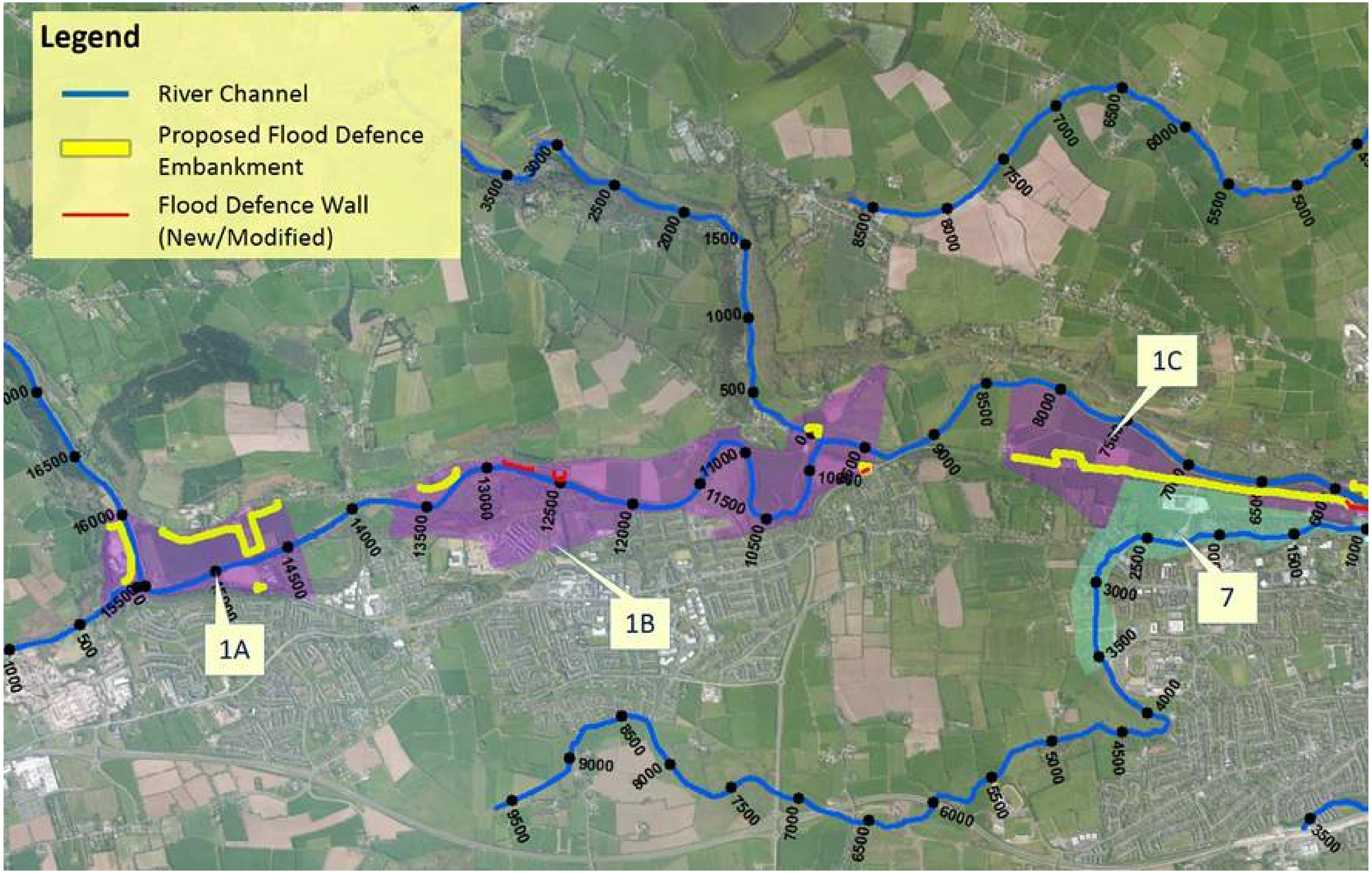


Figure 49: Option 1 – Flow Reduction in South Channel and Direct Defences – City Centre

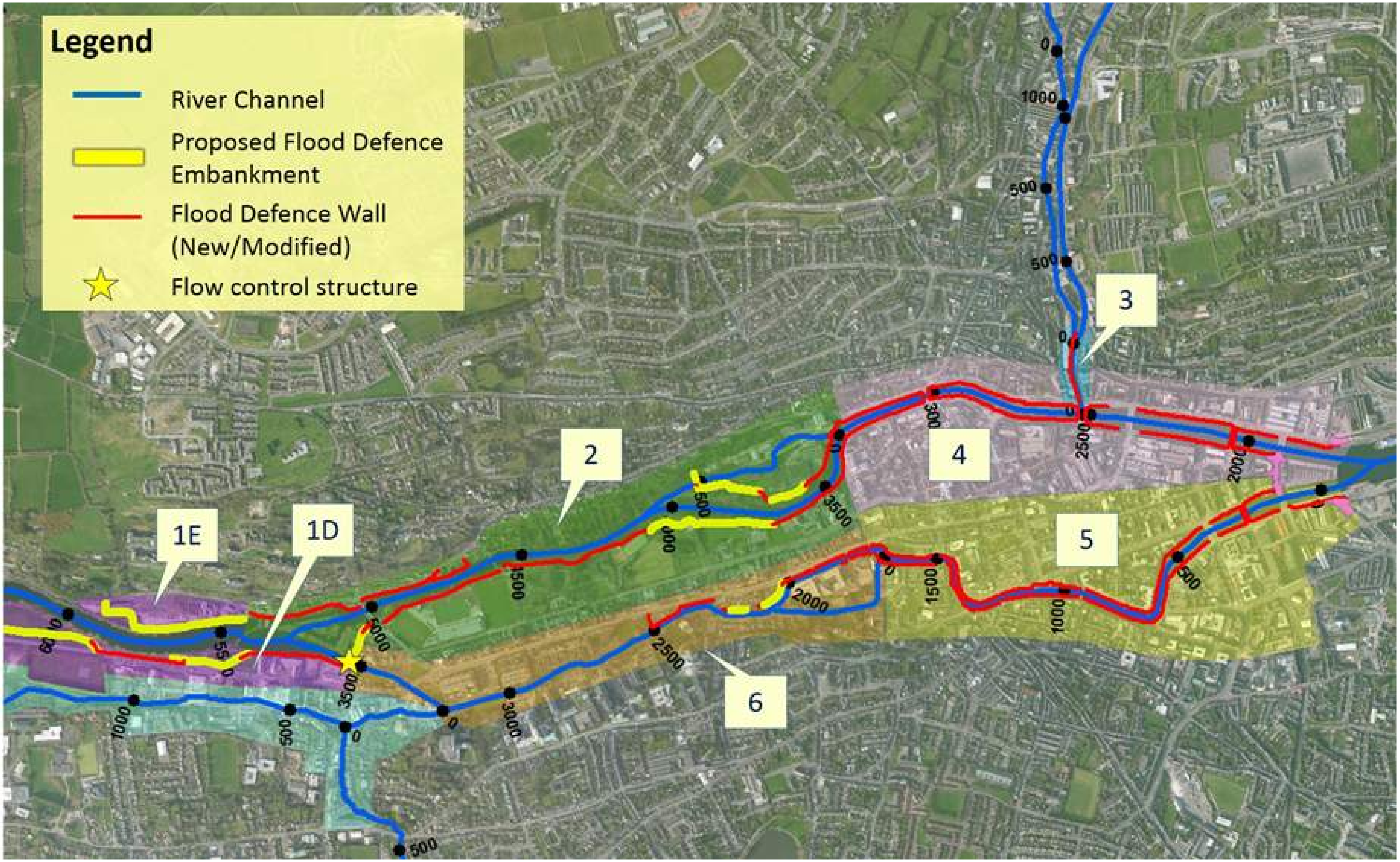


Table 12: Option 1 - Description of Works

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
1 - West of Waterworks Weir	1A	Inniscarra	Lower Lee	15970 - 15570	Proposed flood defence embankment on left bank to flood defence level between 15.9mOD to 16.1mOD, typically 1.8m above existing ground levels. Approximately 485m in length.	
	1A	Inniscarra	Lower Lee	15250 - 14450	Proposed flood defence embankment on left bank to flood defence level between 14.05mOD to 15.25mOD, between 2.0m and 2.5m above existing ground levels. Approximately 1240m in length.	
	1A	Inniscarra	Lower Lee	14775 - 14750	Proposed flood defence embankment on right bank adjacent to Wood Road to flood defence level 15.05mOD, typically 0.8m above existing ground level. Approximately 67m in length. Proposed regrading of road to flood defence level of 14.85mOD, maximum of 0.6m above existing ground levels.	
	1B	Ballincollig	Lower Lee	13170 - 13570	Proposed flood defence embankment on left bank to flood defence level between 12.85mOD to 13.00mOD, typically 2.0m above existing ground level. Approximately 320m in length.	
	1B	Ballincollig	Lower Lee	12890 - 12705	Proposed reinforced concrete flood defence wall to flood defence level of 12.5mOD, typically 1.0m above existing ground level. Approximately 25m in length. Proposed sheet pile flood defence wall on left bank to flood defence level between 12.3mOD to 12.5mOD, between 1.3m and 1.7m above existing ground level. Approximately 195m in length. Proposed reinforced concrete flood defence wall to flood defence level of 12.3mOD, typically 1m above existing ground levels Approximately 20m in length.	
	1B	Ballincollig	Lower Lee	12550 - 12485	Proposed sheet pile flood defence wall to flood defence level of 11.9mOD, typically 1.5m above existing ground level. Approximately 90m length. Proposed reinforced concrete flood defence wall to flood defence level 11.9mOD, typically 0.6m above existing ground levels at either end of sheet pile defence. Approximately 45m and 27m in length respectively.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
1 - West of Waterworks Weir	1B	Leemount	Lower Lee / Shournagh	9810 - 9790	Proposed flood defence embankment on left bank to flood defence level 9.05mOD, typically 1.2m above existing ground level. Approximately 150m in length. Proposed sheet pile flood defence wall to flood defence level of 8.85mOD, typically 1m above existing ground levels Approximately 75m in length. Proposed regrading of road to flood defence level of 8.85mOD, up to 1.0m above existing ground levels.	
	1B	Leemount	Lower Lee	9500 - 9450	Proposed reinforced concrete flood defence wall to flood defence level of 9.1mOD, typically 1.5m above existing ground level, approximately 45m long. Proposed embankment to flood defence level of 9.3mOD, typically 1.7m above existing ground levels at either end of reinforced concrete defence. Approximately 50m and 20m in length respectively.	
	1C	Inchigaggin/ Carrigrohane Road – Right Bank	Lower Lee	8350 - 5900	Proposed flood defence embankment on left bank to flood defence level between 6.4mOD to 7.65mOD, between 1.0m to 1.8m high above existing ground level, approximately 2400m long.	
	1C	Carrigrohane Road – Right Bank	Lower Lee	5900 -5625	Proposed flood defence wall to flood defence level of 6.0mOD, typically 1m above existing ground level, approximately 315m long.	
	1C	Carrigrohane Road – Right Bank	Lower Lee	5700 - 5400	Proposed flood defence embankment to flood defence level 6.05mOD, typically 2.0m above existing ground level, approximately 250m long.	
	1D	Victoria Cross – Right Bank	Lower Lee South Channel	C01 5375 - 5280 C02 3750 - 3535	Proposed flood defence wall to be constructed to a level between 5.8mOD to 5.85mOD, between 1.2 to 1.6m above existing ground levels. Approximately 350m in length. From C02_3700 to C01_5350 for approximately 100m length, the top 0.6m of the wall is to be glass.	
	1D	Victoria Cross – Right Bank	South Channel (CO2)	C02 3540	Proposed flow regulation structure. The width of the channel is to be reduced to 15m.	The flow regulation structure will be closed during flood events to divert flow to the North Channel.

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	1E	Lee Road	Lower Lee	5900 - 5410	Existing embankment to be refurbished and raised to flood defence level between 6.05mOD to 6.4mOD, between 0.9m to 1.2m above existing ground levels, approximately 480m long. Proposed regrading of road to flood defence level of 6.2mOD at chainage 5900 to 5840. Proposed reinforced concrete flood defence wall to flood defence level of 5.85mOD, at chainage 5603 (23m length) and chainage 5527 (17m length), both approximately 20m long.	
2A NNC - North of North Channel West	2A	Victoria Cross – Left Bank	Lower Lee	5425 - 5100	Proposed reinforced concrete flood defence wall to flood defence level between 5.8mOD to 5.85mOD, between 1.2m to 1.5m above existing ground levels, approximately 290m long.	
	2A	Victoria Cross – Left Bank	North Channel	5095 - 5030	Proposed sheet pile flood defence wall to flood defence level 5.8mOD, between 1.2 to 2m above existing dry side ground levels and typically 0.6m above floor level, approximately 90m long.	
	2A	Victoria Cross/ Sunday's Well Road	North Channel	5020 - 4785	Proposed sheet pile flood defence wall to flood defence level between 4.75mOD to 4.9mOD, between 1.2m to 1.3m above existing ground levels, approximately 250m in length.	
	2A	Sunday's Well Road	North Channel	4785 - 4665	Proposed sheet pile flood defence wall to flood defence level of 5.25mOD, up to 3.2m above existing ground levels, approximately 110m long. Proposed reinforced concrete wall to flood defence level of 5.5mOD, at chainage 4785, typically 2m above existing ground levels, approximately 37m in length.	
	2A	Distillery Fields	River Lee Distillery Branch	130	Proposed headwall and penstock.	
	2A	Distillery Fields	North Channel	3940 - 3730	Proposed flood defence embankment to flood defence level between 4.9mOD to 5.15mOD, between 0.7m to 2.8m above existing ground levels, approximately 230m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
2A NNC - North of North Channel West	2A	Distillery Fields	North Channel	3740 - 3680	Proposed reinforced concrete flood defence wall to flood defence level of 4.7mOD, typically 0.7m above existing ground levels, approximately 55m in length.	
	2A	Distillery Fields	North Channel	3680 - 3550	Proposed flood defence embankment to flood defence level of 4.9mOD, between 1.0m to 1.5m above existing ground levels, approximately 120m in length.	
	2A	Distillery Fields	North Channel	3550 - 3355	Proposed reinforced concrete flood defence wall to flood defence level of 4.60mOD, between 0.15m to 1.1m above existing ground levels, approximately 165m in length.	
	2A	Distillery Fields	North Channel	3353 - 3308	Proposed reinforced concrete flood defence parapet to flood defence level of 4.60mOD, typically 1.2m above existing ground levels, approximately 30m in length.	
	2A	Distillery Fields	North Channel	3320	Proposed penstock to be placed on upstream face of the existing bridge.	
	2A	Wise’s Quay	North Channel	3310 - 3304	Proposed reinforced concrete flood defence wall to flood defence level of 4.60mOD, typically 1.2m to 1.5m above proposed ground levels, approximately 43m in length. Proposed re-alignment and re-grading of Wise's Quay. Pedestrian access from St. Vincent's Bridge to be regraded to achieve a crest level at flood defence level of 4.60mOD.	
	2B	Victoria Cross – Right Bank	Lower Lee - South Channel	5100 - 5050	Proposed flood defence embankment to flood defence level 6.0mOD, typically 1.9m above existing ground levels, approximately 85m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
2B CIW - South of North Channel West	2B	Victoria Cross – Right Bank	Lower Lee - North Channel	5060 - 5030	Proposed reinforced concrete flood defence wall to flood defence level of 5.80mOD, up to 1.2m above existing ground levels, approximately 40m in length.	
	2B	Mardyke	North Channel	5004 - 4943	Proposed elevated landing and regrading to a flood defence level of 5.55mOD, typically 2.1m above existing ground levels, approximately 60m in length.	
	2B	Mardyke	North Channel	4993 - 4591	Proposed reinforced concrete flood defence wall to flood defence level between 5.1 to 5.5mOD, typically 1.5m above existing wall level, approximately 405m in length. With remediation of existing wall, approximately 60m in length.	
	2B	Mardyke	North Channel	4640 - 4540	Proposed embankment and ramping to flood defence level of 5.1mOD, between 1.1m to 2.1m above existing ground levels, approximately 90m in length. Proposed footpath regrading to 3.9mOD.	
	2B	Fitzgerald Park	North Channel	4573 - 4320	Proposed 1.2m high glass flood defence wall constructed on a 1.1m high reinforced concrete flood defence wall to flood defence level 5.10mOD, approximately 260m in length. Proposed embankments and ramping to elevated footpath at 3.9mOD behind flood defence wall, approximately 300m in length.	
	2B	Fitzgerald Park	North Channel	4315 - 4090	Proposed sheet pile wall to be constructed in channel to flood defence level 5.1mOD, between 1.2m to 2.0m above proposed ground level, approximately 250m in length. With 30m length of 1.6m high glass wall between chainage 4244 to 4213.	
	2B	Mardyke Walk	North Channel	4110 - 3680	Proposed flood defence embankment to flood defence level between 4.9mOD to 5.15mOD, between 1.0m to 2.65m above existing ground levels, approximately 405m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2B	Mardyke Walk / Dyke Parade	North Channel	3688 - 3425	Proposed sheet pile flood defence wall to flood defence level between 4.65mOD to 4.7mOD, typically 1.5m above existing ground levels, approximately 305m in length.	
3A River Kiln	3	North City Link Road	Kiln River	40 - 260	New reinforced concrete flood defence wall to flood defence level of 3.8mOD, between 0.3m to 0.6m above existing ground levels. Approximately 140m length. Guard railing to be installed on top of proposed wall to 1.2m above existing ground level (0.6m railing). Existing foundation walls to be grouted and resealed.	
	3	North City Link Road	Kiln River	66 - 93	Existing double windows to have local defences fitted externally - defences required to flood defence level of 3.8mOD, typically 0.6m above the bottom of the window.	
	3	North City Link Road	Kiln River	10 - 250	Existing bridge joints (approximately 11 joints) to be resealed to ensure capacity for upward seepage.	
4A NNC - North of North Channel East	4A	North Mall	North Channel	3308 - 3055	Proposed reinforced concrete flood defence wall to flood defence level between 4.35mOD to 4.6mOD, typically 1.2m above existing ground levels, approximately 270m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4A	Pope’s Quay	North Channel	3015 - 2800	The existing stone parapet is to be maintained at existing level which achieves minimum flood defence level of 4.1mOD as part of the flood defence system, approximately 230m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4A	Pope's Quay / Camden Quay	North Channel	2800 - 2556	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.8mOD, typically 1.2m above existing ground level. Approximately 230m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Proposed glass flood barrier to flood defence level of 4.10mOD on footpath between chainage 2798 and 2783, typically 1.2m above existing ground level. Approximately 12m in length.	
	4A	Camden Place	North Channel	2500 - 2445	The existing stone parapet which achieves minimum flood defence level of 3.6mOD is to be maintained as part of the flood defence system, approximately 50m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4A	St. Patrick's Quay	North Channel	2352 - 2057	New reinforced concrete flood defence parapet to flood defence level of 3.6mOD, typically 0.6 to 1.2m above existing ground levels. Approximately 305m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Includes 3m section of demountable flood defence.	
	4A	St. Patrick's Quay	North Channel	2049 - 1919	New reinforced concrete flood defence parapet to flood defence level of 3.5mOD, typically 0.6m above existing ground levels. Approximately 130m in length. With 3m length of demountable flood barrier at western end.	
	4A	Penrose's Quay	North Channel	1886 - 1720	New reinforced concrete flood defence parapet to flood defence level of 3.4mOD, typically 0.6m above existing ground levels with open railing above to 1.2m guarding height. Approximately 170m length.	
	4A	Horgan's Quay	North Channel	1750 - 1671	Proposed localised ramping of existing road and path levels at Horgan's Quay to achieve flood defence level 3.4mOD. Approximately 61m length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
4B CIE - South of North Channel East	4B	Grenville Place	North Channel	3435 - 3307	New reinforced concrete parapet wall to flood defence level between 4.5mOD to 4.65mOD, typically 1.2m above existing ground level, approximately 100m in length. With grouting of wall, foundation zones and soil backing zones	
	4B	Bachelors' Quay	North Channel	3300 - 3056	New reinforced concrete parapet wall to flood defence level between 4.25mOD to 4.4mOD, typically 1.2m above existing ground level. Approximately 240m in length. Includes floodgates at western end. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4B	Griffith Bridge	North Channel	3035 - 3020	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 4.35mOD with open railing above to 1.2m guarding height.	
	4B	Kyrl's Quay	North Channel	3004 - 2794	New reinforced concrete parapet wall to flood defence level of 4.1mOD, typically 1.2m above existing ground level. Approximately 220m in length. Includes floodgates at eastern end. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4B	Coal Quay	North Channel	2800 - 2725	New reinforced concrete parapet wall to flood defence level of 3.8mOD, typically 1.2m above existing ground level. Approximately 80m in length. With 15m glass flood barrier between chainage 2780 to 2794. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
4B CIE - South of North Channel East	4B	Coal Quay - Lavitt's Quay	North Channel	2725 - 2560	New reinforced concrete parapet wall to flood defence level of 3.8mOD, typically 1.2m above existing ground level. Approximately 170m in length.	
	4B	Christy Ring Bridge	North Channel	2525	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 3.8mOD with open railing above to 1.2m guarding height.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4B	Lavitt's Quay	North Channel	2500 - 2410	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.6mOD. Approximately 90m in length. With grouting of existing wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4B	Merchant's Quay - Anderson's Quay	North Channel	2345 - 2059	New reinforced concrete flood defence parapet to flood defence level of 3.6mOD, typically 1.2m above existing ground levels. Approximately 295m in length. Demountable barrier between chainage 2059 to 2061. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4B	Anderson's Quay	North Channel	2055 - 2045	Proposed steel flood defence parapet is to be constructed along bridge footpath to flood defence level of 3.60mOD.	
	4B	Anderson's Quay	North Channel	2047 - 1919	New reinforced concrete flood defence parapet to flood defence level of 3.5mOD, typically 0.6m above existing ground levels, with open railing above to 1.2m guarding height. Approximately 150m in length. Demountable barrier between chainage 2044 to 2047. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4B	Custom House St.	North Channel	1900	The existing road and footpath are to be re-graded to flood defence level 3.40mOD. Approximately 140 m in length, from Michael Collins Bridge to Eamonn DeValera Bridge.	
5A CIE - North of South Channel East	5A	Lapp's Quay East	South Channel	240 - 140	Proposed glass flood defence wall to flood defence level of 3.40mOD, typically 0.9m above existing ground levels, with 0.4m high flood barriers and demountable access gates at regular intervals. Approximately 100m in length.	
	5A	Clontarf Bridge	South Channel	250	Proposed demountable pedestrian access gates to flood defence level of 3.50mOD across footpaths.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5A	Lapp's Quay West	South Channel	360 - 260	Proposed reinforced concrete flood defence parapet to flood defence level of 3.5mOD, typically 0.6m above existing ground levels with 0.6m high guardrail. Approximately 105m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Morrison's Quay	South Channel	700 - 390	Proposed reinforced concrete parapet to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 320m in length. Wall typically 0.6m high with 0.6m high railing installed on top.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	5A	Father Mathew Quay	South Channel	940 - 700	Proposed reinforced concrete parapet to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 220m in length. Wall typically 0.6m high with 0.6m high railing installed on top.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	5A	South Mall Properties	South Channel	1010 - 950	Proposed sheet pile wall to 3.00mOD. Approximately 60m in length. With pedestrian access ramp.	
	5A	Grand Parade Quay	South Channel	1100 - 1010	Proposed reinforced concrete wall to flood defence level of 3.50mOD, with 0.5m high flood flip up barriers at regular intervals. Approximately 115m in length.	
	5A	Dun Mhuire	South Channel	1175 - 1134	Raising of four window sills and existing stone wall to flood defence level 3.50mOD, typically 0.15m above existing levels and waterproofing of existing wall. Approximately 36m in length.	
5A CIE - North of South Channel East	5A	City Car Park	South Channel	1200 - 1134	Proposed 0.2m concrete kerb to raise existing ground levels to flood defence level 3.50mOD. Approximately 70m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Beamish and Crawford Site	South Channel	1457 - 1210	Proposed sheet pile wall to flood defence level 3.5mOD. Approximately 250m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5A	Wandesford-Hanover St Properties	South Channel	1500 - 1457	Proposed reinforced concrete flood defence parapet to flood defence level of 3.5mOD, typically 1.2m above existing ground levels. Approximately 20m in length. Local raising of flood defence line along balconies to flood defence level of 3.50mOD, typically 0.1m above existing ground levels between chainage 1476 to 4796. Approximately 20m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Labour Exchange	South Channel	1583 - 1500	New reinforced concrete flood defence parapet to flood defence level 3.5mOD, typically 0.6m above existing ground levels with 0.6m of railing fitted on top. Approximately 63m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Waterside Quay	South Channel	1638 - 1583	Proposed sheet pile wall to be constructed in channel to flood defence level of 3.50mOD. Approximately 55m in length.	
	5A	Fisherman's Wharf	South Channel	1720 - 1638	Local raising of flood defence line along balconies and restaurant boardwalk to flood defence level of 3.50mOD, typically 0.3m above existing ground levels. Approximately 90m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	St. Finbarre's Bridge	South Channel	1738 - 1733	Proposed reinforced concrete flood defence wall to flood defence level 3.7mOD, typically 0.75m high above ground levels. Approximately 11m in length on either side of bridge.	
5B SSC - South of South Channel East	5B	Albert Quay East - Victoria Road	South Channel	0	Existing road to be re-graded to achieve flood defence level of 3.40mOD.	
	5B	Albert Quay East	South Channel	105 - 0	Proposed reinforced concrete wall to flood defence level of 3.40mOD, typically 0.6m above existing ground levels with guard railings making up the height to 1.2m above existing ground levels. Approximately 175m in length. With steel plate defence to flood defence level of 3.40mOD at chainage 100 to 105.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5B	Albert Quay	South Channel	240 - 150	Proposed sheet pile wall to flood defence level of 3.40mOD, typically 0.6m above existing ground levels with approx. 0.6m high railing. Approximately 90m in length.	Existing wharf to be demolished and reconstruction works to be undertaken along entire quay length.
	5B	Terence MacSweeny Quay	South Channel	350 - 255	Proposed reinforced concrete wall to flood defence level of 3.50mOD, between 0.3m to 0.6m above existing ground levels with guard railings making up the height to 1.2m above existing ground levels. Approximately 95m in length.	Road and footpath to be regraded locally.
	5B	Union Quay	South Channel	700 - 390	Proposed reinforced concrete parapet combined with glass flood defence walls at regular intervals, to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 300m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5B	George's Quay	South Channel	935 - 705	Proposed reinforced concrete wall combined with glass flood defence walls at regular intervals, to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 240m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5B	Sullivan's Quay	South Channel	1195 - 950	Proposed reinforced concrete wall to flood defence level of 3.50mOD, typically 1.2m above existing ground levels including 0.6m high railing. Approximately 235m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5B	French's Quay	South Channel	1320 - 1210	Existing parapet extends over flood defence level of 3.50mOD and is to be maintained. Approximately 125m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5B	Crosse's Green Quay	South Channel	1480 - 1325	Proposed sheet pile wall to be constructed in channel to flood defence level of 3.50mOD. Minimum guard height of 1.2m to be maintained along proposed parapet (typically 0.6m above existing ground levels with 0.6m railing fitted on top). Approximately 145m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5B	Wandesford Quay	South Channel	1615 - 1500	Proposed reinforced concrete wall to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 105m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5B	Crawford Hall	South Channel	1750 - 1648	Proposed reinforced concrete wall combined with glass flood defence walls at regular intervals, to flood defence level of 3.50mOD, typically 1.2m above existing ground levels. Approximately 100m in length.	
6A CIW - North of South Channel West	6A	Lancaster Quay	South Channel	1750 - 1738	Proposed reinforced concrete flood defence wall to level of approximately 3.7mOD to tie into adjacent existing walls (flood defence level is 3.5mOD). Approximately 12m in length.	
	6A	Lancaster Quay	South Channel	1790 - 1750	Existing wall to be maintained, with grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Approximately 42m in length.	
	6A	Lancaster Lodge Bridge	South Channel	1805 - 1790	Proposed reinforced concrete flood defence wall to flood defence level 3.5mOD, typically 0.75m high above ground levels. Approximately 8m in length on either side of bridge.	
	6A	Lancaster Quay	South Channel	1906 - 1805	Existing wall to be maintained, with grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Approximately 100m in length.	
6A CIW - North of South Channel West	6A	Hotel Bridge	South Channel	1923 - 1906	Proposed reinforced concrete flood defence wall to flood defence level 3.5mOD, typically 0.75m high above ground levels. Approximately 9m in length on either side of bridge.	
	6A	Lancaster Quay	South Channel	2002 - 1923	Existing wall to be maintained, with grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Approximately 100m in length.	
	6A	Western Road	South Channel	2008 - 2003	Proposed reinforced concrete flood defence wall to flood defence level 3.55mOD, typically 0.45m above existing ground levels. Approximately 5m in length.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	6A	Western Road	South Channel	2118 - 2005	Proposed flood defence embankment to flood defence level of 3.75mOD, typically 0.65m above existing ground levels. Approximately 95m in length.	
	6A	Western Road	South Channel	2151 - 2118	Existing wall to be remediated to ensure capacity for flood loading. Existing gate accesses to be removed and replaced with flood defence wall to flood defence level 3.55mOD, typically 1.6m above existing ground levels. Approximately 30m in length.	
	6A	Western Road	South Channel	2237 - 2191	Proposed flood defence embankment to flood defence level 3.75mOD, typically 0.4m above existing ground levels. Approximately 45m in length.	
	6A	Western Road	South Channel	2265 - 2250	Proposed sheet pile flood defence wall to flood defence level 3.55mOD, typically 0.35m above existing ground levels. Approximately 20m in length.	
	6A	Western Road	South Channel	2352 - 2315	Reinforced concrete wall to flood defence level 3.55mOD, typically 0.35m above existing ground levels. Approximately 55m in length.	
	6A	Western Road	South Channel	2395 - 2352	Existing wall to be maintained, with grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Approximately 50m in length.	
	6A	Western Road	South Channel	2500 - 2400	Proposed sheet pile flood defence wall to flood defence level of 3.55mOD. Wall to extend to 1.2m above existing garden levels to provide guarding height. Approximately 90m in length. Proposed reinforced concrete flood defence wall to flood defence level 3.55mOD, typically 0.5m above existing ground levels at either end of sheet pile defence. Approximately 10m and 40m in length respectively.	

Option 1						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
6B SSC - South of South Channel West	6B	Lancaster Lodge Quay	South Channel	1830 - 1735	Proposed concrete kerb to be constructed to a flood defence level of 3.50mOD, typically 0.2m above existing ground levels. Approximately 80m in length. Proposed reinforced concrete wall to flood defence level of 3.50mOD, typically 0.60m above existing ground levels. Approximately 10m in length.	
7A Curragheen and Glasheen Rivers	7	Curragheen and Glasheen				With flow regulation structure in place in the South Channel, no defences or river diversions are required for Curragheen and Glasheen Rivers.

12.4 Option 2 – Isolation of South Channel and Direct Defences

As with all three options, there are a number of prerequisite measures that must be implemented, including Revised Dam Operating Procedures, Flood Forecasting System and Early Warning Service, and designation of Upland Washlands.

In Area 1, west of the Waterworks Weir, only one measure - direct defences - is considered for all three options. The alignment is illustrated in Figure 50.

This differentiator in this option is the inclusion of two flow control structures at the either end of the South Channel to prevent flow entering the South Channel from either the upstream or downstream ends.

The isolation of the channel is beneficial for the South Channel, Areas 5 and 6, as it will prevent flow entering the South Channel during both tidal and fluvial flood events, thus removing the requirement for raised defences and quay wall remedial works along the South Channel.

However, there is insufficient capacity within the South Channel to store the potential flow incoming from the Curragheen River, Glasheen River and the drainage from the city with the two flow control structures in operation. Taking account of these constraints, both the tidal and fluvial design flood events are to be considered.

In a tidal design event, both flow control structures will have to be closed, therefore diversion of the Curragheen and Glasheen towards the River Lee is required. Flow control structures are required at the confluence between the Curragheen and the Glasheen, and to divert the Curragheen through a culvert to the River Lee downstream of the Waterworks Weir as shown in Figure 41.

The model results showed there is a significant increase in water levels on the Curragheen upstream of the diversion structure. This will result in extensive defences required along the Curragheen as far as Model Farm Road.

This arrangement also results in the requirement of more significant flood defences in the North Channel West (Area 2) in comparison to Option 1. When the south channel is isolated, there is a resulting increase in water levels in the western portion of this reach of up to +0.45m in comparison to Option 3 with no flow management. The defence levels are greater as the Curragheen and the Glasheen are also contributing to the flow. The defences required within North Channel East (Area 4) are similar for all three options as this reach is tidally dominated.

In a fluvial design event, the optimum solution is to operate the flow control structures as per Option 1, i.e. only closing the flow control structure at the head of the South Channel and allowing the Curragheen and Glasheen to discharge through the South Channel. This is because there is sufficient existing capacity within the South Channel for these flows and there will be no requirement for additional defences in South Channel, Areas 5 and 6.

The alignment of the defences within the city centre is illustrated in Figure 52.

Full detailed of the proposed defences associated with Option 1 are included in Table 13 below.

Figure 50: Option 2 – Isolation of South Channel and Direct Defences – West of City

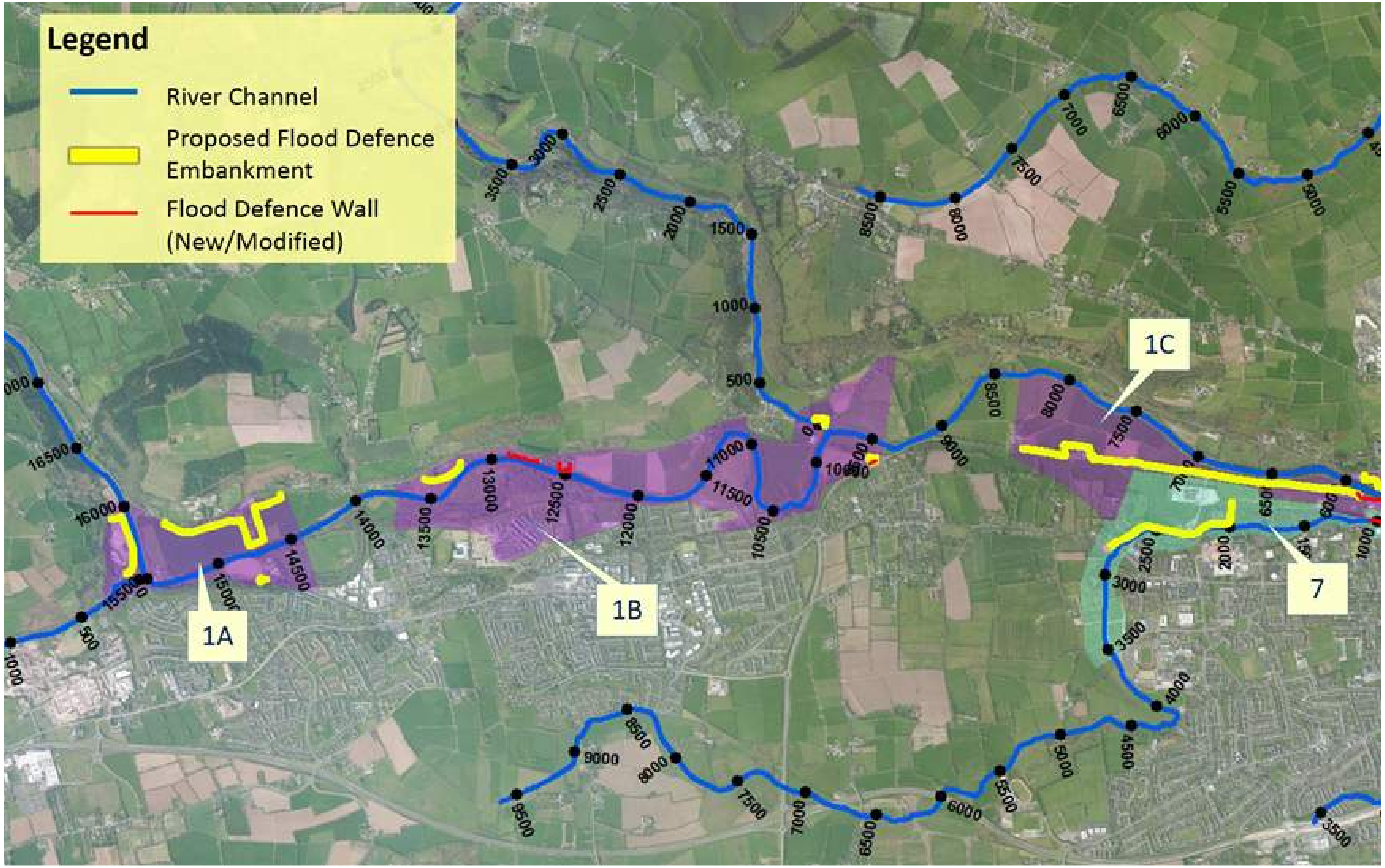


Figure 51: Option 2 – Isolation of South Channel and Direct Defences – Curragheen and Glasheen

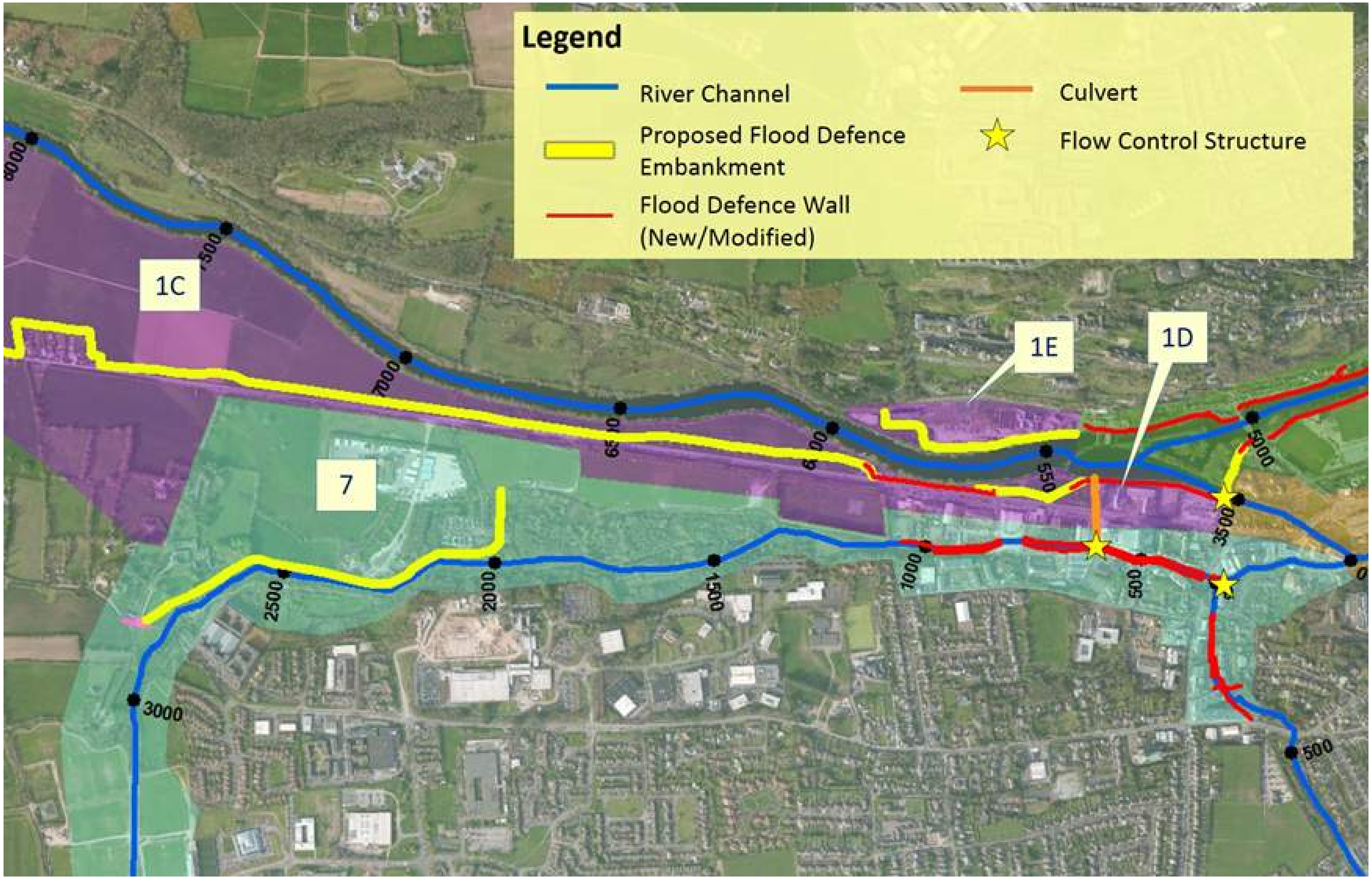


Figure 52: Option 2 – Isolation of South Channel and Direct Defences – City Centre

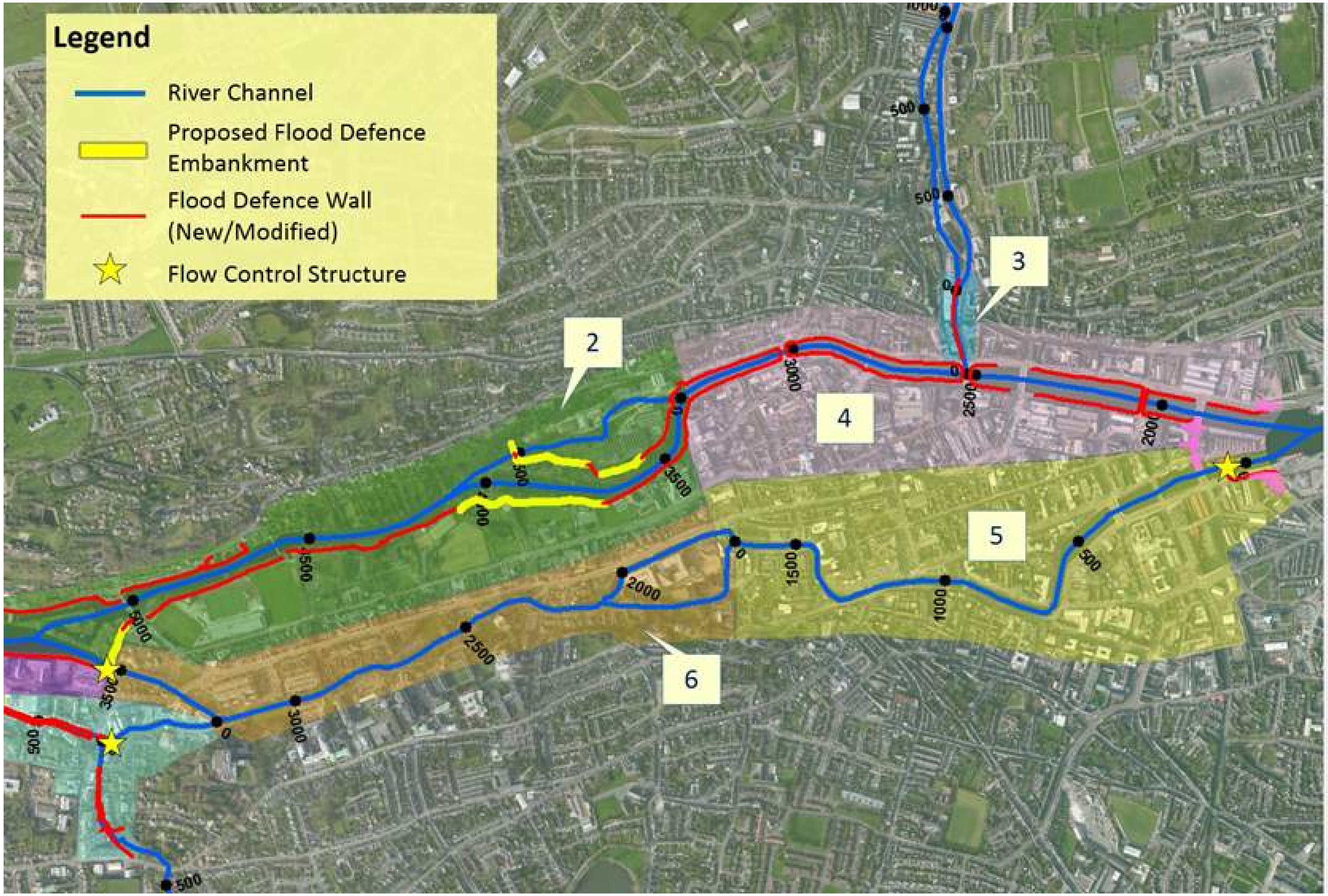


Table 13: Option 2 - Description of Works

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
1 West of Waterworks Weir	1A	Inniscarra			As Table 12 above	
	1B	Ballincollig / Leemount			As Table 12 above	
	1C	Inchigaggin/ Carrigrohane Road – Right Bank			As Table 12 above	
	1D	Victoria Cross – Right Bank			As Table 12 above	
	1E	Lee Road			As Table 12 above	
2A NNC - North of North Channel West	2A	Victoria Cross – Left Bank	Lower Lee	5425 - 5100	As Table 12 above	
	2A	Victoria Cross – Left Bank	North Channel	5095 - 5030	As Table 12 above	
	2A	Victoria Cross / Sunday's Well Road	North Channel	5020 - 4785	As Table 12 above	
	2A	Sunday's Well Road	North Channel	4785 - 4665	Proposed sheet pile flood defence wall to flood defence level of 5.3mOD, up to 3.25m above existing ground levels, approximately 110m long. Proposed reinforced concrete wall to flood defence level of 5.5mOD, at chainage 4785, typically 2m above existing ground levels, approximately 37m in length.	
	2A	Distillery Fields	River Lee Distillery Branch	130	Proposed headwall and penstock.	

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2A	Distillery Fields	North Channel	3940 - 3730	Proposed flood defence embankment to flood defence level between 5.05mOD to 5.3mOD, between 0.85m to 2.9m above existing ground levels, approximately 230m in length.	
	2A	Distillery Fields	North Channel	3740 - 3680	Proposed reinforced concrete flood defence wall to flood defence level of 4.85mOD, typically 0.85m above existing ground levels, approximately 55m in length.	
	2A	Distillery Fields	North Channel	3680 - 3550	Proposed flood defence embankment to flood defence level of 5.05mOD, between 1.15m to 1.65m above existing ground levels, approximately 120m in length.	
	2A	Distillery Fields	North Channel	3550 - 3355	Proposed reinforced concrete flood defence wall to flood defence level of 4.80mOD, between 0.35m to 1.3m above existing ground levels, approximately 165m in length.	
	2A	Distillery Fields	North Channel	3353 - 3308	Proposed reinforced concrete flood defence parapet to flood defence level of 4.80mOD, typically 1.4m above existing ground levels, approximately 30m in length.	
	2A	Distillery Fields	North Channel	3320	Proposed penstock to be placed on upstream face of the existing bridge.	
	2A	Wise's Quay	North Channel	3310 - 3304	Proposed reinforced concrete flood defence wall to flood defence level of 4.80mOD, typically 1.4m to 1.7m above proposed ground levels, approximately 43m in length. Proposed re-alignment and re-grading of Wise's Quay. Pedestrian access from St. Vincent's Bridge to be regraded to achieve a crest level at flood defence level of 4.80mOD.	
2B CIW - South of North Channel	2B	Victoria Cross – Right Bank	Lower Lee - South Channel	5100 - 5050	As Table 12 above	
	2B	Victoria Cross – Right Bank	Lower Lee - North Channel	5060 - 5030	As Table 12 above	

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2B	Mardyke	North Channel	5004 - 4943	As Table 12 above	
	2B	Mardyke	North Channel	4993 - 4591	As Table 12 above	
	2B	Mardyke	North Channel	4640 - 4540	As Table 12 above	
	2B	Fitzgerald Park	North Channel	4573 - 4320	Proposed 1.2m high glass flood defence wall constructed on a 1.15m high reinforced concrete flood defence wall to flood defence level 5.15mOD, approximately 260m in length. Proposed embankments and ramping to elevated footpath at 3.95mOD behind flood defence wall, approximately 300m in length.	
	2B	Fitzgerald Park	North Channel	4315 - 4090	Proposed sheet pile wall to be constructed in channel to flood defence level 5.2mOD, between 1.3m to 2.1m above proposed ground level, approximately 250m in length. With 30m length of 1.6m high glass wall between chainage 4244 to 4213.	
	2B	Mardyke Walk	North Channel	4110 - 3680	Proposed flood defence embankment to flood defence level between 5.05mOD to 5.3mOD, between 1.15m to 2.8m above existing ground levels, approximately 405m in length.	
	2B	Mardyke Walk / Dyke Parade	North Channel	3688 - 3425	Proposed sheet pile flood defence wall to flood defence level 4.85mOD, typically 1.7m above existing ground levels, approximately 305m in length.	
3A River Kiln	3	North City Link Road	Kiln River		As Table 12 above	
4A NNC - North of North	4A	North Mall	North Channel	3308 - 3055	Proposed reinforced concrete flood defence wall to flood defence level between 4.55mOD to 4.8mOD, typically 1.4m above existing ground levels, approximately 270m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4A	Pope's Quay	North Channel	3015 - 2800	As Table 12 above	
	4A	Pope's Quay / Camden Quay	North Channel	2800 - 2556	As Table 12 above	
	4A	Camden Place	North Channel	2500 - 2445	As Table 12 above	
	4A	St. Patrick's Quay	North Channel	2352 - 2057	As Table 12 above	
	4A	St. Patrick's Quay	North Channel	2049 - 1919	As Table 12 above	
	4A	Penrose's Quay	North Channel	1886 - 1720	As Table 12 above	
	4A	Horgan's Quay	North Channel	1750 - 1671	As Table 12 above	
4B CIE - South of North Channel East	4B	Grenville Place	North Channel	3435 - 3307	New reinforced concrete parapet wall to flood defence level between 4.7mOD to 4.85mOD, typically 1.4m above existing ground level, approximately 100m in length. With grouting of wall, foundation zones and soil backing zones	
	4B	Bachelors' Quay	North Channel	3300 - 3056	New reinforced concrete parapet wall to flood defence level between 4.45mOD to 4.6mOD, typically 1.4m above existing ground level. Approximately 240m in length. Includes floodgates at western end. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be re-graded locally to reduce the relative height of proposed flood defence wall.
	4B	Griffith Bridge	North Channel	3035 - 3020	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 4.50mOD, typically between 0.35 and 0.9m above existing ground level, with open railing above to 1.2m guarding height. Approximately 70m in length on upstream side of bridge and 40m in length on downstream side of bridge.	

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4B	Kyrl's Quay	North Channel	3004 - 2794	As Table 12 above	
	4B	Coal Quay	North Channel	2800 - 2725	As Table 12 above	
	4B	Coal Quay - Lavitt's Quay	North Channel	2725 - 2560	As Table 12 above	
4B CIE - South of North Channel East	4B	Christy Ring Bridge	North Channel	2525	As Table 12 above	
	4B	Lavitt's Quay	North Channel	2500 - 2410	As Table 12 above	
	4B	Merchant's Quay - Anderson's Quay	North Channel	2345 - 2059	As Table 12 above	
	4B	Anderson's Quay	North Channel	2055 - 2045	As Table 12 above	
	4B	Anderson's Quay	North Channel	2047 - 1919	As Table 12 above	
	4B	Custom House St.	North Channel	1900	As Table 12 above	
5A CIE - North of South Channel East	5A	North of South Channel East	South Channel		No defences required	With flow regulation structures in place in the South Channel, at the head and the mouth, no defences are required in this area.

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
5B SSC - South of	5B	Albert Quay East - Victoria Road	South Channel	0	Existing road to be re-graded to achieve flood defence level of 3.40mOD.	
	5B	Albert Quay East	South Channel	50 - 0	Proposed reinforced concrete wall to flood defence level of 3.40mOD, typically 0.6m above existing ground levels with guard railings making up the height to 1.2m above existing ground levels. Approximately 136m in length. Proposed flow regulation structure.	The flow regulation structure will be closed during tidal flood events to prevent flow entering the South Channel.
	5B	South of South Channel East	South Channel		No defences required	With flow regulation structures in place in the South Channel, at the head and the mouth, no defences are required for rest of this area.
6A CIW - North of South Channel West	6A	North of South Channel West			No defences required	With flow regulation structures in place in the South Channel, at the head and the mouth, no defences are required in this area.
6B SSC - South of South Channel West	6B	South of South Channel West			No defences required	With flow regulation structures in place in the South Channel, at the head and the mouth, no defences are required in this area.

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
7A Curragheen and Glasheen Rivers	7	Curragheen - Left bank	Curragheen	315 - 0	No defences	No defences required in this area as during flood events, the flow will be diverted to the new culvert at chainage 602.
	7	Curragheen - Left bank	Curragheen	315	Proposed flow regulation structure to divert Glasheen River from flowing east into South Channel to flow west towards new culvert.	
	7	Curragheen - Left bank	Curragheen	337 - 315	Proposed reinforced concrete flood defence wall, typically 3.0m above existing ground levels. Approximately 22m in length.	
	7	Victoria Bridge	Curragheen	354 - 337	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone, typically 1.7 to 2.5m above ground levels on bridge. Approximately 15m in length on upstream side of bridge and 9m in length on downstream side of bridge.	
	7	Curragheen - Left bank	Curragheen	562 - 354	Proposed reinforced concrete flood defence wall, typically 2.7m above existing ground levels. Approximately 204m in length. Demolition of existing footbridge at chainage 562.	
	7	Curragheen - Left bank	Curragheen	602 - 562	Proposed reinforced concrete flood defence wall, typically 3.2m above existing ground levels. Approximately 39m in length.	
	7	Curragheen - Left bank	Curragheen	602	Proposed flow regulation structure to divert Curragheen River. New 2no. 6m wide x 2.75m high culverts, approximately 150m in length, connecting Curragheen to River Lee, downstream of Waterworks Weir.	
	7	Cork County Library - Bridge	Curragheen	610 - 602	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet, typically 2.0m high above ground levels. Approximately 11m in length on upstream and downstream side of bridge.	
	7	Curragheen - Left bank	Curragheen	660 - 610	Proposed reinforced concrete flood defence wall, typically 3.0m above existing ground levels. Approximately 45m in length.	

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	7	Curragheen - Left bank	Curragheen	740 - 660	Proposed sheet pile flood defence wall, typically 3.0m above existing ground level. Approximately 82m length.	
	7	Curragheen - Left bank	Curragheen	775 - 740	Proposed reinforced concrete flood defence wall, typically 3.0m above existing ground levels. Approximately 35m in length.	
	7	Culvert	Curragheen	825 - 775	Proposed reinforced concrete flood defence wall, typically between 2.3m and 3.0m high above ground levels. Approximately 9m in length on upstream side of bridge and 12.5m in length on downstream side of existing culvert.	
	7	Curragheen - Left bank	Curragheen	1055 - 825	Proposed reinforced concrete flood defence wall, typically 3.0m above existing ground levels. Approximately 229m in length.	
	7	Curragheen - Left bank	Curragheen	2190 - 1980	Proposed flood defence embankment, typically 2.9m above existing ground levels. Approximately 333m in length.	
	7	Curragheen - Left bank	Curragheen	2330 - 2190	Proposed flood defence embankment, typically 1.8m above existing ground levels. Approximately 133m in length.	
	7	Curragheen - Left bank	Curragheen	2830 - 2330	Proposed flood defence embankment, typically 2.2m above existing ground levels. Approximately 535m in length.	
	7	Curragheen - Left bank	Curragheen	2830	Proposed road regrading, typically between 0 and 1.1m above existing ground levels, approximately 50m in length.	
	7	Curragheen - Right bank	Curragheen	315 - 0	No defences required.	No defences required in this area as during flood events, the flow will be diverted to the new culvert at chainage 602.
	7	Curragheen - Right bank	Curragheen	354 - 315	Proposed reinforced concrete flood defence wall, typically 3.2m above existing ground levels. Approximately 22m in length.	
	7	Curragheen - Right bank	Curragheen	560 - 354	Proposed reinforced concrete flood defence wall, typically 2.9m above existing ground levels. Approximately 206m in length.	
	7	Curragheen - Right bank	Curragheen	602 - 562	Proposed reinforced concrete flood defence wall, typically 3.2m above existing ground levels. Approximately 36m in length.	

Option 2						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	7	Curragheen - Right bank	Curragheen	775 - 610	Proposed reinforced concrete flood defence wall, typically 2.0m above existing ground levels. Approximately 163m in length.	
	7	Curragheen - Right bank	Curragheen	980 - 825	Proposed reinforced concrete flood defence wall, typically 2.8m above existing ground levels. Approximately 153m in length.	
	7	Glasheen - Left bank	Glasheen	70.5 - 0	Existing culvert to be demolished. New culvert to be constructed - 4m wide x 1.5m high. Approximately 75m in length.	
	7	Victoria Cross Culvert	Glasheen	70.5	Proposed reinforced concrete flood defence wall, typically 2.2m above existing ground levels. Approximately 9m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	7	Glasheen - Left bank	Glasheen	162 - 70.5	Proposed reinforced concrete flood defence wall, typically 2.8m above existing ground levels. Approximately 92m in length.	
	7	Ashbrook Heights Culvert	Glasheen	170 - 162	Proposed reinforced concrete flood defence wall, typically 2.6m above existing ground levels. Approximately 18m in length on upstream side of bridge and 10m in length on downstream side of bridge. Existing culvert to be demolished. New culvert to be constructed - 4m wide x 1m high. Approximately 9m in length.	
	7	Glasheen - Left bank	Glasheen	215 - 170	Proposed reinforced concrete flood defence wall, typically 0.5m above existing ground levels, tying into existing high ground levels. Approximately 42m in length.	
	7	Glasheen - Left bank	Glasheen	350 - 235	Proposed reinforced concrete flood defence wall, typically 2.8m above existing ground levels. Approximately 120m in length.	
	7	Glasheen - Right bank	Glasheen	162 - 70.5	Proposed reinforced concrete flood defence wall, typically between 2.2 and 3.1m above existing ground levels. Approximately 90m in length.	
	7	Glasheen - Right bank	Glasheen	285 - 170	Proposed reinforced concrete flood defence wall, typically 3.1m above existing ground levels. Approximately 115m in length.	

12.5 Option 3 – Direct Defences Only

As with all three options, there are a number of prerequisite measures that must be implemented, including Revised Dam Operating Procedures, Flood Forecasting System and Early Warning Service, and designation of Upland Washlands.

In Area 1, west of the Waterworks Weir, only one measure - direct defences - is considered for all three options. The alignment is illustrated in Figure 50.

This option comprises direct defences only and does not consider flow management measures within the South Channel.

In this option, there is a requirement for direct defences within the Curragheen and the Glasheen River (Area 7), as per Figure 53.

There will be significant defences required within the South Channel (Areas 5 and 6) as there are no flow control structures in place.

The extents of the defence required for North Channel West (Area 2) will be reduced somewhat as the flow is reduced in comparison to Options 1 and 2. The defences required within North Channel East (Area 4) are similar for all three options as this reach is tidally dominated.

The alignment of the defences within the city centre is illustrated in Figure 54.

Full detailed of the proposed defences associated with Option 1 are included in Table 14 below.

Figure 53: Option 3 – Direct Defences – Curragheen and Glasheen

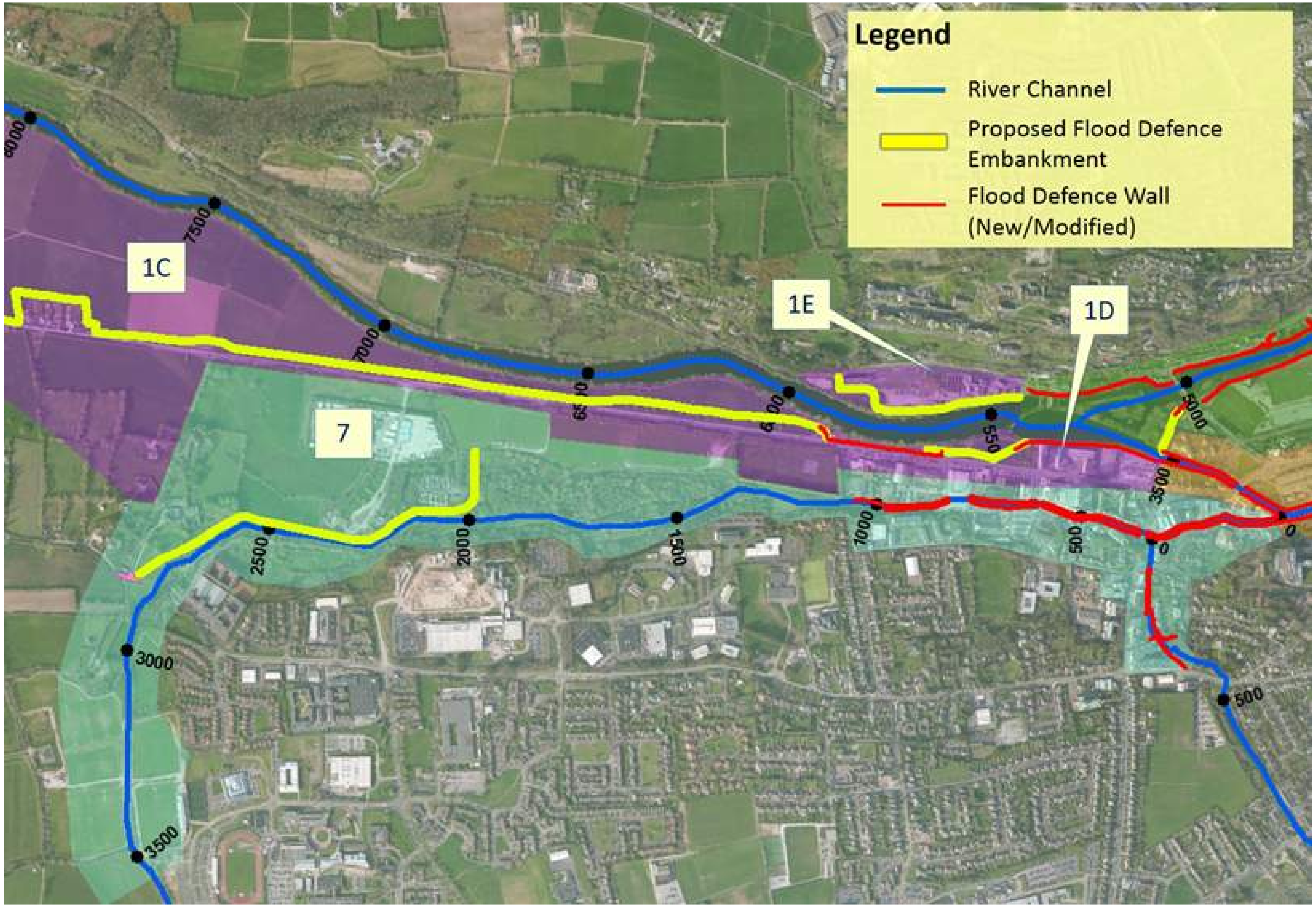


Figure 54: Option 3 – Direct Defences – City Centre

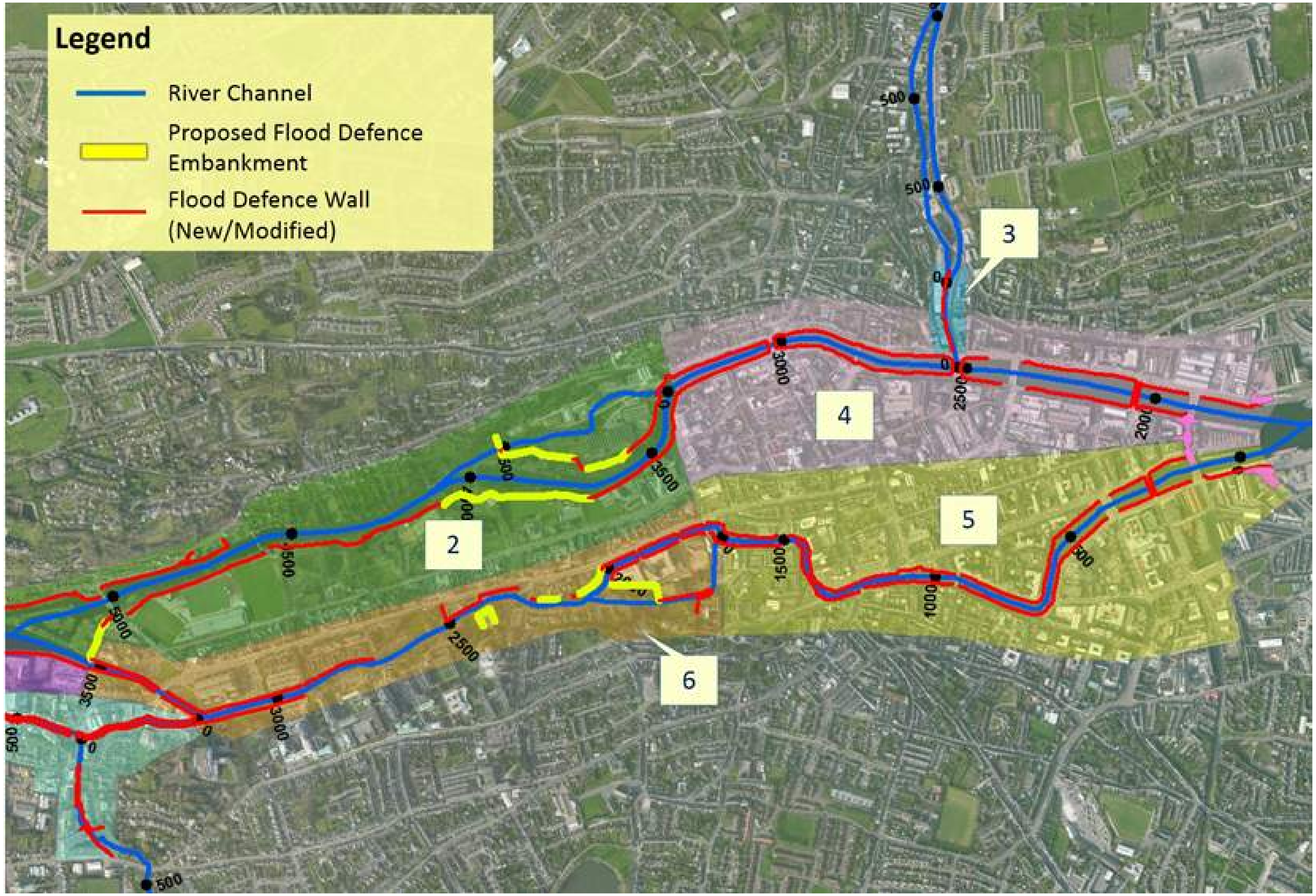


Table 14: Option 3 - Description of Works

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
1 West of Waterworks Weir	1A	Inniscarra			As Table 12 above	
	1B	Ballincollig / Leemount			As Table 12 above	
	1C	Inchigaggin/ Carrigrohane Road – Right Bank			As Table 12 above	
	1D	Victoria Cross – Right Bank	Lower Lee South Channel	C01 5375 - 5280 C02 3750 - 3535	Proposed flood defence wall to be constructed to a level between 5.45mOD to 5.6mOD, between 0.8 to 1.3m above existing ground levels. Approximately 350m in length. From C02_3700 to C01_5350 for approximately 100m length, the top 0.6m of the wall is to be glass.	
	1E	Lee Road			As Table 12 above	
2A NNC - North of North Channel West	2A	Victoria Cross – Left Bank	Lower Lee	5425 - 5100	Proposed reinforced concrete flood defence wall to flood defence level between 5.4mOD to 5.45mOD, between 0.8m to 1.1m above existing ground levels, approximately 290m long.	
	2A	Victoria Cross – Left Bank	North Channel	5095 - 5030	Proposed sheet pile flood defence wall to flood defence level 5.4mOD, between 0.8 to 1.6m above existing dry side ground levels and typically 0.2m above floor level, approximately 90m long.	
	2A	Victoria Cross / Sunday's Well Road	North Channel	5020 - 4785	Proposed sheet pile flood defence wall to flood defence level between 4.4mOD to 4.55mOD, between 0.85m to 0.95m above existing ground levels, approximately 250m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2A	Sunday's Well Road	North Channel	4785 - 4665	Proposed sheet pile flood defence wall to flood defence level of 4.9mOD, up to 2.85m above existing ground levels, approximately 110m long. Proposed reinforced concrete wall to flood defence level of 5.15mOD, at chainage 4785, typically 1.65m above existing ground levels, approximately 37m in length.	
	2A	Distillery Fields	River Lee Distillery Branch	130	Proposed headwall and penstock.	
	2A	Distillery Fields	North Channel	3940 - 3730	Proposed flood defence embankment to flood defence level between 4.55mOD to 4.8mOD, between 0.35m to 2.45m above existing ground levels, approximately 230m in length.	
	2A	Distillery Fields	North Channel	3740 - 3680	Proposed reinforced concrete flood defence wall to flood defence level of 4.35mOD, typically 0.35m above existing ground levels, approximately 55m in length.	
	2A	Distillery Fields	North Channel	3680 - 3550	Proposed flood defence embankment to flood defence level of 4.55mOD, between 0.65m to 1.15m above existing ground levels, approximately 120m in length.	
	2A	Distillery Fields	North Channel	3550 - 3355	Proposed reinforced concrete flood defence wall to flood defence level of 4.25mOD, between 0m to 0.75m above existing ground levels, approximately 110m in length.	
	2A	Distillery Fields	North Channel	3353 - 3308	Proposed reinforced concrete flood defence parapet to flood defence level of 4.25mOD, typically 0.85m above existing ground levels, approximately 30m in length.	
	2A	Distillery Fields	North Channel	3320	Proposed penstock to be placed on upstream face of the existing bridge.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2A	Wise's Quay	North Channel	3310 - 3304	Proposed reinforced concrete flood defence wall to flood defence level of 4.25mOD, typically 0.85m to 1.15m above proposed ground levels, approximately 43m in length. Proposed re-alignment and re-grading of Wise's Quay. Pedestrian access from St. Vincent's Bridge to be regraded to achieve a crest level at flood defence level of 4.25mOD.	
	2B	Victoria Cross – Right Bank	Lower Lee - South Channel	5100 - 5050	Proposed flood defence embankment to flood defence level 5.6mOD, typically 1.5m above existing ground levels, approximately 85m in length.	
	2B	Victoria Cross – Right Bank	Lower Lee - North Channel	5060 - 5030	Proposed reinforced concrete flood defence wall to flood defence level of 5.40mOD, up to 0.8m above existing ground levels, approximately 40m in length.	
	2B	Mardyke	North Channel	5004 - 4943	Proposed elevated landing and regrading to a flood defence level of 5.15mOD, typically 1.7m above existing ground levels, approximately 60m in length.	
	2B	Mardyke	North Channel	4993 - 4591	Proposed reinforced concrete flood defence wall to flood defence level between 4.75 to 5.15mOD, typically 1.15m above existing wall level, approximately 405m in length. With remediation of existing wall, approximately 60m in length.	
2B CIW - South of North Channel West	2B	Mardyke	North Channel	4640 - 4540	Proposed embankment and ramping to flood defence level of 4.75mOD, between 0.75m to 1.75m above existing ground levels, approximately 90m in length. Proposed footpath regrading to 3.55mOD.	
	2B	Fitzgerald Park	North Channel	4573 - 4320	Proposed 1.2m high glass flood defence wall constructed on a 0.7m high reinforced concrete flood defence wall to flood defence level 4.7mOD, approximately 260m in length. Proposed embankments and ramping to elevated footpath at 3.5mOD behind flood defence wall, approximately 300m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	2B	Fitzgerald Park	North Channel	4315 - 4090	Proposed sheet pile wall to be constructed in channel to flood defence level 4.7mOD, between 0.8m to 1.6m above proposed ground level, approximately 250m in length. With 30m length of 1.6m high glass wall between chainage 4244 to 4213.	
	2B	Mardyke Walk	North Channel	4110 - 3680	Proposed flood defence embankment to flood defence level between 4.55mOD to 4.75mOD, between 0.6m to 2.3m above existing ground levels, approximately 405m in length.	
	2B	Mardyke Walk / Dyke Parade	North Channel	3688 - 3425	Proposed sheet pile flood defence wall to flood defence level between 4.3mOD to 4.35mOD, typically 1.15m above existing ground levels, approximately 305m in length.	
3A River Kiln	3	North City Link Road	Kiln River		As Table 12 above	
4A NNC - North of North Channel East	4A	North Mall	North Channel	3308 - 3055	Proposed reinforced concrete flood defence wall to flood defence level between 4.05mOD to 4.3mOD, typically 0.9m above existing ground levels, approximately 270m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4A	Pope’s Quay	North Channel	3015 - 2800	The existing stone parapet is to be maintained at existing level which achieves minimum flood defence level of 4.0mOD as part of the flood defence system, approximately 230m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4A	Pope's Quay / Camden Quay	North Channel	2800 - 2556	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.7mOD, typically 1.1m above existing ground level. Approximately 230m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Proposed glass flood barrier to flood defence level of 4.10mOD on footpath between chainage 2798 and 2783, typically 1.2m above existing ground level. Approximately 12m in length.	
	4A	Camden Place	North Channel	2500 - 2445	The existing stone parapet which achieves minimum flood defence level of 3.5mOD is to be maintained as part of the flood defence system, approximately 50m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4A	St. Patrick's Quay	North Channel	2352 - 2057	New reinforced concrete flood defence parapet to flood defence level of 3.55mOD, typically 0.55 to 1.15m above existing ground levels. Approximately 305m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Includes 3m section of demountable flood defence.	
	4A	St. Patrick's Quay	North Channel	2049 - 1919	As Table 12 above	
	4A	Penrose's Quay	North Channel	1886 - 1720	As Table 12 above	
	4A	Horgan's Quay	North Channel	1750 - 1671	As Table 12 above	
4B CIE - South of	4B	Grenville Place	North Channel	3435 - 3307	New reinforced concrete parapet wall to flood defence level between 4.15mOD to 4.3mOD, typically 0.85m above existing ground level, approximately 100m in length. With grouting of wall, foundation zones and soil backing zones	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4B	Bachelors' Quay	North Channel	3300 - 3056	New reinforced concrete parapet wall to flood defence level between 3.95mOD to 4.1mOD, typically 0.9m above existing ground level. Approximately 240m in length. Includes floodgates at western end. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4B	Griffith Bridge	North Channel	3035 - 3020	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 4.15mOD, typically between 0 and 0.55m above existing ground level, with open railing above to 1.2m guarding height. Approximately 70m in length on upstream side of bridge and 40m in length on downstream side of bridge.	
	4B	Kyrl's Quay	North Channel	3004 - 2794	New reinforced concrete parapet wall to flood defence level of 4.0mOD, typically 1.1m above existing ground level. Approximately 220m in length. Includes floodgates at eastern end. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
	4B	Coal Quay	North Channel	2800 - 2725	New reinforced concrete parapet wall to flood defence level of 3.7mOD, typically 1.1m above existing ground level. Approximately 80m in length. With 15m glass flood barrier between chainage 2780 to 2794. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	Road and footpath to be regraded locally to reduce the relative height of proposed flood defence wall.
4B CIE - South of North Channel East	4B	Coal Quay - Lavitt's Quay	North Channel	2725 - 2560	New reinforced concrete parapet wall to flood defence level of 3.7mOD, typically 1.1m above existing ground level. Approximately 170m in length.	
	4B	Christy Ring Bridge	North Channel	2525	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 3.7mOD, typically 0.3m above ground levels, with open railing above to 1.2m guarding height. Approximately 70m in length on upstream side of bridge and 75m in length on downstream side of bridge.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	4B	Lavitt's Quay	North Channel	2500 - 2410	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.55mOD. Approximately 90m in length. With grouting of existing wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4B	Merchant's Quay - Anderson's Quay	North Channel	2345 - 2059	New reinforced concrete flood defence parapet to flood defence level of 3.55mOD, typically 1.15m above existing ground levels. Approximately 295m in length. Demountable barrier between chainage 2059 to 2061. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	4B	Anderson's Quay	North Channel	2055 - 2045	Proposed steel flood defence parapet is to be constructed along bridge footpath to flood defence level of 3.55mOD, typically 0.4m above ground levels. Approximately 60m in length on upstream and downstream side of bridge.	
	4B	Anderson's Quay	North Channel	2047 - 1919	As Table 12 above	
	4B	Custom House St.	North Channel	1900	As Table 12 above	
5A CIE - North of South Channel East	5A	Lapp's Quay East	South Channel	240 - 140	As Table 12 above	
	5A	Clontarf Bridge	South Channel	250	As Table 12 above	
	5A	Lapp's Quay West	South Channel	360 - 260	As Table 12 above	
	5A	Morrison's Quay	South Channel	700 - 390	As Table 12 above	
	5A	Father Mathew Quay	South Channel	940 - 700	As Table 12 above	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5A	South Mall Properties	South Channel	1010 - 950	As Table 12 above	
	5A	Grand Parade Quay	South Channel	1100 - 1010	As Table 12 above	
	5A	Dun Mhuire	South Channel	1175 - 1134	As Table 12 above	
5A CIE - North of South Channel East	5A	City Car Park	South Channel	1200 - 1134	As Table 12 above	
	5A	Beamish and Crawford Site	South Channel	1457 - 1210	Proposed sheet pile wall to flood defence level 3.55mOD. Approximately 250m in length.	
	5A	Wandesford-Hanover St Properties	South Channel	1500 - 1457	Proposed reinforced concrete flood defence parapet to flood defence level of 3.6mOD, typically 1.3m above existing ground levels. Approximately 20m in length. Local raising of flood defence line along balconies to flood defence level of 3.60mOD, typically 0.2m above existing ground levels between chainage 1476 to 4796. Approximately 20m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Labour Exchange	South Channel	1583 - 1500	New reinforced concrete flood defence parapet to flood defence level 3.6mOD, typically 0.7m above existing ground levels with 0.45m of railing fitted on top. Approximately 63m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	5A	Waterside Quay	South Channel	1638 - 1583	Proposed sheet pile wall to be constructed in channel to flood defence level of 3.60mOD. Approximately 55m in length.	
	5A	Fisherman's Wharf	South Channel	1720 - 1638	Local raising of flood defence line along balconies and restaurant boardwalk to flood defence level of 3.6mOD, typically 0.4m above existing ground levels. Approximately 90m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5A	St. Finbarre's Bridge	South Channel	1738 - 1733	Proposed reinforced concrete flood defence wall to flood defence level 3.7mOD, typically 0.75m high above ground levels. Approximately 11m in length on either side of bridge.	
5B SSC - South of South Channel East	5B	Albert Quay East - Victoria Road	South Channel	0	As Table 12 above	
	5B	Albert Quay East	South Channel	105 - 0	As Table 12 above	
	5B	Albert Quay	South Channel	240 - 150	As Table 12 above	
	5B	Terence MacSweeny Quay	South Channel	350 - 255	As Table 12 above	
	5B	Union Quay	South Channel	700 - 390	As Table 12 above	
	5B	George's Quay	South Channel	935 - 705	As Table 12 above	
	5B	Sullivan's Quay	South Channel	1195 - 950	As Table 12 above	
	5B	French's Quay	South Channel	1320 - 1210	As Table 12 above	
	5B	Crosse's Green Quay	South Channel	1480 - 1325	As Table 12 above	
	5B	Wandesford Quay	South Channel	1615 - 1500	Proposed reinforced concrete wall to flood defence level of 3.6mOD, typically 1.3m above existing ground levels. Approximately 105m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	5B	Crawford Hall	South Channel	1750 - 1648	Proposed reinforced concrete wall combined with glass flood defence walls at regular intervals, to flood defence level of 3.6mOD, typically 1.3m above existing ground levels. Approximately 100m in length.	
6A CIW - North of South Channel West	6A	Lancaster Quay	South Channel	1750 - 1738	Proposed reinforced concrete flood defence wall to flood level of 3.70mOD to tie into adjacent existing walls, typically 0.9m above existing ground levels. Approximately 12m in length.	
	6A	Lancaster Quay	South Channel	1790 - 1750	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.7mOD, typically 1m above existing ground level. Approximately 42m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	6A	Lancaster Lodge Bridge	South Channel	1805 - 1790	Proposed reinforced concrete flood defence wall to flood defence level 3.75mOD, typically 1.05m high above ground levels. Approximately 8m in length on either side of bridge.	
	6A	Lancaster Quay	South Channel	1906 - 1805	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 3.75mOD, typically 1m above existing ground level. Approximately 100m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
6A CIW - North of South Channel West	6A	Hotel Bridge	South Channel	1923 - 1906	Proposed reinforced concrete flood defence wall to flood defence level 3.8mOD, typically 0.6m high above ground levels. Approximately 9m in length on either side of bridge.	
	6A	Lancaster Quay	South Channel	2002 - 1923	Existing wall to be maintained, with grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary. Approximately 100m in length.	
	6A	Western Road	South Channel	2008 - 2003	Proposed reinforced concrete flood defence wall to flood defence level 3.85mOD, typically 0.75m above existing ground levels. Approximately 5m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	6A	Western Road	South Channel	2118 - 2005	Proposed flood defence embankment to flood defence level of 3.9mOD, typically 0.8m above existing ground levels. Approximately 95m in length.	
	6A	Western Road	South Channel	2151 - 2118	Existing wall to be remediated or replaced to achieve flood defence level of 4.0mOD. Existing gate accesses to be removed and replaced with flood defence wall to flood defence level 4.0mOD, typically 2.0m above existing ground levels. Approximately 30m in length.	
	6A	Western Road	South Channel	2237 - 2191	Proposed flood defence embankment to flood defence level 4.0mOD, typically 0.8m above existing ground levels. Approximately 45m in length.	
	6A	Western Road	South Channel	2265 - 2250	Proposed sheet pile flood defence wall to flood defence level 4.05mOD, typically 0.85m above existing ground levels. Approximately 20m in length.	
	6A	Western Road	South Channel	2352 - 2315	Reinforced concrete wall to flood defence level 4.25mOD, typically 1.05m above existing ground levels. Approximately 55m in length.	
	6A	Western Road	South Channel	2395 - 2352	Proposed increase in wall height with concrete strip and cut limestone cladding and reinstatement of existing coping stone to achieve a flood defence height of 4.3mOD, typically 0.7m above existing ground level. Approximately 50m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	6A	Western Road	South Channel	2500 - 2400	Proposed sheet pile flood defence wall to flood defence level of 4.3mOD. Approximately 90m in length. Proposed reinforced concrete flood defence wall to flood defence level 4.3mOD, typically 1.25m above existing ground levels at either end of sheet pile defence. Approximately 10m and 40m in length respectively.	
	6A	Castlewhite Apartments	South Channel	2886 - 2722	Proposed reinforced concrete flood defence wall to flood defence level of 4.75mOD, typically 0.9m above existing ground levels. Approximately 155m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	6A	Castlewhite Apartments	South Channel	2928 - 2887	Proposed reinforced concrete flood defence wall to flood defence level of 4.75mOD, typically 1.4m above existing ground levels. Approximately 35m in length.	
	6A	UCC Carpark	South Channel	3145 - 2928	Proposed reinforced concrete flood defence wall to flood defence level of 5.0mOD, typically between 1 and 2.5m above existing ground levels. Approximately 210m in length.	
	6A	Footbridge	South Channel	3145	Proposed demountable pedestrian access gates to flood defence level of 5.15mOD across footpaths.1.65m high above existing ground levels.	
	6A	UCC Western Gateway Building	South Channel	3340 - 3145	Proposed reinforced concrete flood defence wall to flood defence level of 5.2mOD, typically 1.5m above existing ground levels. Approximately 165m in length.	
	6A	Sacred Heart	South Channel	3535 - 3340	Proposed reinforced concrete flood defence wall to flood defence level of 5.3mOD, typically 1.5m above existing ground levels. Approximately 195m in length.	
6B SSC – South of South Channel West	6B	Lancaster Lodge Quay	South Channel	1790 - 1735	Proposed concrete wall to be constructed to a flood defence level of 3.70mOD, typically 0.4m above existing ground levels. Approximately 60m in length. Proposed reinforced concrete wall to flood defence level of 3.80mOD, typically 0.90m above existing ground levels. Approximately 10m in length.	
	6B	Lancaster Gate Quay	South Channel	1915 - 1801	Proposed reinforced concrete flood defence wall to flood defence level of 3.75mOD, typically 0.35m above existing ground levels. Guard railing to be installed on top of proposed wall to 1.2m above existing ground level. Approximately 105m in length.	
6B SSC – South of South Channel West	6B	River Lee Hotel	South Channel	2116 - 1915	Proposed 0.15m concrete kerb to raise existing ground levels to flood defence level 3.85mOD. Guard railing to be installed on top of proposed wall to 1.2m above existing ground level. Approximately 111m in length.	
	6B	Gilabbey Weir	Gilabbey Mill Race	C03_425 - C03_300	Proposed flood defence embankment to flood defence level of 4.0mOD, typically 2.75m above existing ground levels. Approximately 150m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	6B	St. Aloysius School	Gilabbey Mill Race	C03_300 - C03_150	Proposed reinforced concrete wall to flood defence level of 4.0mOD, typically 2.75m above existing ground levels. Approximately 225m in length.	
	6B	Glucksman Art Gallery	South Channel	2500 - 2305	Proposed flood defence embankment to flood defence level of 4.25mOD, typically 1.1m above existing ground levels. Approximately 105m in length.	
	6B	UCC Carpark / Brookfield	South Channel	3190 - 2928	Proposed reinforced concrete flood defence wall to flood defence level between 4.75mOD and 5.0mOD, typically 1.55m to 2.25m above existing ground levels. Approximately 265m in length.	
	6B	Victoria Mills Apartments	South Channel	3320 - 3220	Proposed reinforced concrete flood defence wall to flood defence level of 5.25mOD, typically 1.8m above existing ground levels. Approximately 100m in length.	
	6B	Victoria Cross	South Channel	3535 - 3340	Proposed reinforced concrete flood defence wall to flood defence level of 5.3mOD, typically 1.0m above existing ground levels. Approximately 190m in length.	
7A Curragheen and Glasheen Rivers	7	Curragheen - Left bank	Curragheen	337 - 0	Proposed reinforced concrete flood defence wall to flood defence level 5.2mOD, typically between 0m and 1.3m above existing ground levels. Approximately 330m in length.	
	7	Victoria Bridge	Curragheen	354 - 337	Existing bridge parapets to achieve flood defence level of 5.55mOD and to tie into adjacent flood defence walls.	
	7	Curragheen - Left bank	Curragheen	562 - 354	Proposed reinforced concrete flood defence wall to flood defence level 5.75mOD, typically 1.2m above existing ground levels. Approximately 204m in length. Demolition of existing footbridge at chainage 562.	
	7	Curragheen - Left bank	Curragheen	602 - 562	Proposed reinforced concrete flood defence wall to flood defence level 6.0mOD, typically 2.0m above existing ground levels. Approximately 39m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	7	Cork County Library - Bridge	Curragheen	610 - 602	The existing steel bridge railing/parapet is to be removed and replaced with a new solid steel flood defence parapet to flood defence level of 6.2mOD with open railing above to 1.2m guarding height, typically 1m above ground levels. Approximately 11m in length on upstream and downstream side of bridge.	
	7	Curragheen - Left bank	Curragheen	660 - 610	Proposed reinforced concrete flood defence wall to flood defence level 6.30mOD, typically 2.1m above existing ground levels. Approximately 45m in length.	
	7	Curragheen - Left bank	Curragheen	740 - 660	Proposed sheet pile flood defence wall to flood defence level of 6.30mOD, typically 2.1m above existing ground level. Approximately 80m length.	
	7	Curragheen - Left bank	Curragheen	775 - 740	Proposed reinforced concrete flood defence wall to flood defence level 6.30mOD, typically 2.1m above existing ground levels. Approximately 35m in length.	
	7	Culvert	Curragheen	825 - 775	Proposed reinforced concrete flood defence wall to flood defence level 6.30mOD, typically between 1.3m and 2m above ground levels. Approximately 9m in length on upstream side of existing culvert and 12.5m in length on downstream side of existing culvert.	
	7	Curragheen - Left bank	Curragheen	1055 - 825	Proposed reinforced concrete flood defence wall to flood defence level 6.4mOD, typically 2.1m above existing ground levels. Approximately 224m in length. Demolition of existing bridge at chainage 1055.	
	7	Curragheen - Left bank	Curragheen	2190 - 1980	Proposed flood defence embankment to flood defence level 6.85mOD, typically between 2.5m above existing ground levels. Approximately 333m in length.	
	7	Curragheen - Left bank	Curragheen	2330 - 2190	Proposed flood defence embankment to flood defence level 6.9mOD, typically 1.4m above existing ground levels. Approximately 133m in length.	
	7	Curragheen - Left bank	Curragheen	2830 - 2330	Proposed flood defence embankment to flood defence level to 7.0mOD, typically 1.8m above existing ground levels. Approximately 535m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	7	Curragheen - Left bank	Curragheen	2830	Proposed elevated landing and regrading to a flood defence level of 7.5mOD, typically between 0.1 and 1.3m above existing ground levels, approximately 50m in length.	
	7	Curragheen - Right bank	Curragheen	337 - 0	Proposed reinforced concrete flood defence wall to flood defence level 5.20mOD, typically between 0.1 and 1m above existing ground levels. Approximately 349m in length.	
	7	Curragheen - Right bank	Curragheen	560 - 354	Proposed reinforced concrete flood defence wall to flood defence level 5.75mOD, typically 1.45m above existing ground levels. Approximately 206m in length.	
	7	Curragheen - Right bank	Curragheen	602 - 562	Proposed reinforced concrete flood defence wall to flood defence level 6.0mOD, typically 2.0m above existing ground levels. Approximately 36m in length.	
	7	Curragheen - Right bank	Curragheen	775 - 610	Proposed reinforced concrete flood defence wall to flood defence level 6.30mOD, typically 1.1m above existing ground levels. Approximately 163m in length.	
	7	Curragheen - Right bank	Curragheen	980 - 825	Proposed reinforced concrete flood defence wall to flood defence level 6.30mOD, typically 1.8m above existing ground levels. Approximately 153m in length.	
	7	Glasheen - Left bank	Glasheen	70.5 - 0	Existing Culvert	
	7	Victoria Cross Culvert	Glasheen	70.5	The existing stone parapet is to be maintained at existing level which achieves minimum flood defence level of 7mOD and to tie into adjacent flood defence walls. Approximately 9m in length. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	7	Glasheen - Left bank	Glasheen	162 - 70.5	Proposed reinforced concrete flood defence wall to flood defence level 7mOD, typically between 0.6 and 2.4m above existing ground levels. Approximately 92m in length.	

Option 3						
Area	**Zone**	**Location**	**Channel**	**Chainage (m)**	**Description**	**Comments**
	7	Ashbrook Heights Culvert	Glasheen	170 - 162	The existing stone parapet is to be maintained at existing level which achieves minimum flood defence level of 7mOD and to tie into adjacent flood defence walls. Approximately 18m in length on upstream side of existing culvert and 10m in length on downstream side of existing culvert. With grouting of wall, foundation zones and soil backing zones, and wall face repointing and repair where necessary.	
	7	Glasheen - Left bank	Glasheen	285 - 170	No defences required.	
	7	Glasheen - Right bank	Glasheen	113 - 70.5	Proposed reinforced concrete flood defence wall to flood defence level 7mOD, typically 0.9m above existing ground levels. Approximately 42m in length.	
	7	Glasheen - Right bank	Glasheen	135 - 113	Proposed flood defence embankment to flood defence level 7.2mOD, typically 1.5m above existing ground levels. Approximately 22m in length.	
	7	Glasheen - Right bank	Glasheen	162 - 135	Proposed reinforced concrete flood defence wall to flood defence level 7mOD, typically 1.8m above existing ground levels. Approximately 26m in length.	
	7	Glasheen - Right bank	Glasheen	285 - 170	Proposed reinforced concrete flood defence wall to flood defence level 7.8mOD, typically 2.6m above existing ground levels. Approximately 104m in length.	

12.6 Summary of Flood Defence Levels

The table below summarises the flood defence levels for each of the options.

Table 15: Flood Defence Levels

					FLOOD DEFENCE LEVEL		
Area		**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
1A Inniscarra	1A	Inniscarra	Lower Lee	15970 - 15570	16mOD - 16.2mOD	16mOD - 16.2mOD	16mOD - 16.2mOD
	1A	Inniscarra	Lower Lee	15250 - 14450	14.05mOD - 15.25mOD	14.05mOD - 15.25mOD	14.05mOD - 15.25mOD
	1A	Inniscarra	Lower Lee	14775 - 14750	15.05mOD	15.05mOD	15.05mOD
1B Ballincollig	1B	Ballincollig	Lower Lee	13170 - 13570	12.85mOD - 13.00mOD	12.85mOD - 13.00mOD	12.85mOD - 13.00mOD
	1B	Ballincollig	Lower Lee	12890 - 12705	12.3mOD - 12.5mOD	12.3mOD - 12.5mOD	12.3mOD - 12.5mOD
	1B	Ballincollig	Lower Lee	12550 - 12485	11.9mOD	11.9mOD	11.9mOD
	1B	Leemount	Lower Lee / Shournagh	9810 - 9790	8.85mOD - 9.05mOD	8.85mOD - 9.05mOD	8.85mOD - 9.05mOD
	1B	Leemount	Lower Lee	9500 - 9450	9.1mOD - 9.3mOD	9.1mOD - 9.3mOD	9.1mOD - 9.3mOD
1C Carrigrohane Road / Inchigaggin	1C	Inchigaggin/ Carrigrohane Road – Right Bank	Lower Lee	8350 - 5900	6.4mOD to 7.65mOD	6.4mOD to 7.65mOD	6.4mOD to 7.65mOD
	1C	Carrigrohane Road – Right Bank	Lower Lee	5900 -5625	6.0mOD	6.0mOD	6.0mOD
	1C	Carrigrohane Road – Right Bank	Lower Lee	5700 - 5400	6.05mOD	6.05mOD	6.05mOD

					FLOOD DEFENCE LEVEL		
Area		**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
1D Kingsley	1D	Victoria Cross – Right Bank	Lower Lee (CO1) - South Channel (CO2)	C01 5375 to 5280 C02 3750 to 3427	5.8mOD - 5.85mOD	5.8mOD - 5.85mOD	5.45mOD - 5.6mOD
1E Lee	1E	Lee Road	Lower Lee	5900 - 5410	6.05mOD - 6.4mOD	6.05mOD - 6.4mOD	6.05mOD - 6.4mOD
2A NNC - North of North Channel West	2A	Victoria Cross – Left Bank	Lower Lee	5425 - 5100	5.8mOD to 5.85mOD	5.8mOD - 5.85mOD	5.4mOD - 5.45mOD
	2A	Victoria Cross – Left Bank	North Channel	5095 - 5030	5.8mOD	5.8mOD	5.4mOD
	2A	Victoria Cross/ Sunday's Well Road	North Channel	5020 - 4785	4.75mOD - 4.9mOD	4.75mOD - 4.9mOD	4.4mOD - 4.55mOD
	2A	Sunday's Well Road	North Channel	4785 - 4665	5.25mOD - 5.5mOD	5.3mOD - 5.5mOD	4.9mOD - 5.15mOD
	2A	Distillery Fields	North Channel	3940 - 3730	4.9mOD - 5.15mOD	5.05mOD - 5.3mOD	4.55mOD - 4.8mOD
	2A	Distillery Fields	North Channel	3740 - 3680	4.7mOD	4.85mOD	4.35mOD
	2A	Distillery Fields	North Channel	3680 - 3550	4.9mOD	5.05mOD	4.55mOD
	2A	Distillery Fields - Wise's Quay	North Channel	3550 - 3304	4.60mOD	4.80mOD	4.25mOD
2B CIW - South of North Channel West	2B	Victoria Cross – Right Bank	Lower Lee - South Channel	5100 - 5050	6.0mOD	6.0mOD	5.6mOD
	2B	Victoria Cross – Right Bank	Lower Lee - North Channel	5060 - 5030	5.80mOD	5.80mOD	5.40mOD
	2B	Mardyke	North Channel	5004 - 4943	5.55mOD	5.55mOD	5.15mOD
	2B	Mardyke	North Channel	4993 - 4591	5.1 - 5.5mOD	5.1 - 5.5mOD	4.75 - 5.15mOD
	2B	Mardyke	North Channel	4640 - 4540	5.1mOD	5.1mOD	4.75mOD

					FLOOD DEFENCE LEVEL		
Area		**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
	2B	Fitzgerald Park	North Channel	4573 - 4320	5.10mOD	5.15mOD	4.7mOD
	2B	Fitzgerald Park	North Channel	4315 - 4090	5.1mOD	5.2mOD	4.7mOD
	2B	Mardyke Walk	North Channel	4110 - 3680	4.9mOD - 5.15mOD	5.05mOD - 5.3mOD	4.55mOD - 4.75mOD
	2B	Mardyke Walk / Dyke Parade	North Channel	3688 - 3425	4.65mOD - 4.7mOD	4.85mOD	4.3mOD - 4.35mOD
3A Kiln	3A	North City Link Road	Kiln River	40 - 260	3.8mOD	3.8mOD	3.8mOD
4A NNC - North of North Channel East	4A	North Mall	North Channel	3308 - 3055	4.35mOD - 4.6mOD	4.55mOD - 4.8mOD	4.05mOD - 4.3mOD
	4A	Pope’s Quay	North Channel	3015 - 2800	4.1mOD	4.1mOD	4.0mOD
	4A	Pope’s Quay / Camden Quay	North Channel	2800 - 2556	3.8mOD - 4.1mOD	3.8mOD - 4.1mOD	3.7mOD - 4.0mOD
	4A	Camden Place	North Channel	2500 - 2445	3.6mOD	3.6mOD	3.5mOD
	4A	St. Patrick's Quay	North Channel	2352 - 2057	3.6mOD	3.6mOD	3.50mOD
	4A	St. Patrick's Quay	North Channel	2049 - 1919	3.5mOD	3.5mOD	3.5mOD
	4A	Penrose's Quay -Horgan's Quay	North Channel	1886 - 1671	3.4mOD	3.4mOD	3.4mOD
4B CIE - South of North Channel East	4B	Grenville Place	North Channel	3435 - 3307	4.5mOD - 4.65mOD	4.7mOD - 4.85mOD	4.15mOD - 4.3mOD
	4B	Bachelors' Quay	North Channel	3300 - 3056	4.25mOD - 4.4mOD	4.45mOD - 4.6mOD	3.95mOD - 4.1mOD
	4B	Griffith Bridge	North Channel	3035 - 3020	4.35mOD	4.50mOD	4.15mOD
	4B	Kyrl's Quay	North Channel	3004 - 2794	4.1mOD	4.1mOD	4.0mOD

					FLOOD DEFENCE LEVEL		
Area		**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
	4B	Coal Quay - Christy Ring Bridge	North Channel	2800 - 2525	3.8mOD	3.8mOD	3.7mOD
	4B	Lavitt's Quay - Anderson's Quay	North Channel	2500 - 2045	3.6mOD	3.6mOD	3.55mOD
	4B	Anderson's Quay	North Channel	2047 - 1919	3.5mOD	3.5mOD	3.5mOD
	4B	Custom House St.	North Channel	1900	3.40mOD	3.40mOD	3.40mOD
5A CIE - North of South Channel East	5A	Lapp's Quay East	South Channel	240 - 140	3.40mOD	-	3.40mOD
	5A	Clontarf Bridge - City Car Park	South Channel	1200 - 250	3.50mOD	-	3.50mOD
	5A	Beamish and Crawford Site	South Channel	1457 - 1210	3.5mOD	-	3.55mOD
	5A	Wandesford-Hanover St Properties - Fisherman's Wharf	South Channel	1720 - 1457	3.5mOD	-	3.6mOD
	5A	St. Finbarre's Bridge	South Channel	1738 - 1733	3.7mOD	-	3.7mOD
5A CIE - South of South Channel East	5B	Albert Quay East	South Channel	105 - 0	3.40mOD	3.40mOD	3.40mOD
	5B	Albert Quay	South Channel	240 - 150	3.40mOD	-	3.40mOD
	5B	Terence MacSweeny Quay - Crosse's Green Quay	South Channel	1480 - 255	3.50mOD	-	3.50mOD
	5B	Wandesford Quay -Crawford Hall	South Channel	1750 - 1500	3.50mOD	-	3.6mOD
6A CIW - North of	6A	Lancaster Quay	South Channel	1750 - 1738	3.7mOD	-	3.70mOD
	6A	Lancaster Quay	South Channel	1790 - 1750	3.5mOD	-	3.7mOD

					FLOOD DEFENCE LEVEL		
Area		Location	Channel	Chainage (m)	OPTION 1	OPTION 2	OPTION 3
	6A	Lancaster Lodge Bridge - Lancaster Quay	South Channel	1906 - 1790	3.5mOD	-	3.75mOD
	6A	Hotel Bridge	South Channel	1923 - 1906	3.5mOD	-	3.8mOD
	6A	Lancaster Quay - Western Road	South Channel	2008 - 1923	3.55mOD	-	3.85mOD
	6A	Western Road	South Channel	2118 - 2005	3.75mOD	-	3.9mOD
	6A	Western Road	South Channel	2151 - 2118	3.55mOD	-	4.0mOD
	6A	Western Road	South Channel	2237 - 2191	3.75mOD	-	4.0mOD
	6A	Western Road	South Channel	2265 - 2250	3.55mOD	-	4.05mOD
	6A	Western Road	South Channel	2352 - 2315	3.55mOD	-	4.25mOD
	6A	Western Road	South Channel	2500 - 2352	3.55mOD	-	4.3mOD
	6A	Castlewhite Apartments	South Channel	2928 - 2722	-	-	4.75mOD
	6A	UCC Carpark	South Channel	3145 - 2928	-	-	5.0mOD
	6A	Footbridge	South Channel	3145	-	-	5.15mOD
	6A	UCC Western Gateway Building	South Channel	3340 - 3145	-	-	5.2mOD
	6A	Sacred Heart	South Channel	3427 - 3340	-	-	5.3mOD
6B SSC -	6B	Lancaster Lodge Quay	South Channel	1790 - 1735	3.50mOD	-	3.70mOD - 3.80mOD

					FLOOD DEFENCE LEVEL		
Area		**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
	6B	Lancaster Gate Quay	South Channel	1830 - 1801	3.50mOD	-	3.75mOD
	6B	Lancaster Gate Quay	South Channel	1915 - 1830	-	-	3.75mOD
	6B	River Lee Hotel	South Channel	2116 - 1915	-	-	3.85mOD
	6B	Gilabbey Mill Race	South Channel	C03_425 - C03_150	-	-	4.0mOD
	6B	Glucksman Art Gallery	South Channel	2500 - 2305	-	-	4.25mOD
	6B	UCC Carpark / Brookfield	South Channel	3190 - 2928	-	-	4.75mOD - 5.0mOD
	6B	Victoria Mills Apartments	South Channel	3320 - 3220	-	-	5.25mOD
	6B	Victoria Cross	South Channel	3527 - 3340	-	-	5.3mOD
7 - Curragheen and Glasheen Rivers	7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	315 - 0	-	-	-
	7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	337 - 315	-	7.2mOD	5.2mOD
	7A	Curragheen and Glasheen Rivers	Victoria Bridge	354 - 337	-	7.2mOD	5.55mOD
	7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	562 - 354	-	7.2mOD	5.75mOD
	7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	602 - 562	-	7.2mOD	6.0mOD
	7A	Curragheen and Glasheen Rivers	Cork County Library - Bridge	610 - 602	-	7.2mOD	6.2mOD

				FLOOD DEFENCE LEVEL		
Area	**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	825 - 610	-	7.2mOD	6.30mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	1055 - 825	-	7.3mOD	6.4mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	2190 - 1980	-	7.7mOD	6.85mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	2330 - 2190	-	7.7mOD	6.9mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	2830 - 2330	-	7.7mOD - 7.8mOD	7.0mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Left bank	2830	-	7.8mOD	7.5mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	315 - 0	-	-	-
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	354 - 315	-	7.2mOD	5.20mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	560 - 354	-	7.2mOD	5.75mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	602 - 562	-	7.2mOD	6.0mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	775 - 610	-	7.2mOD	6.30mOD
7A	Curragheen and Glasheen Rivers	Curragheen - Right bank	980 - 825	-	7.3mOD	6.30mOD
7A	Curragheen and Glasheen Rivers	Victoria Cross Culvert	70.5	-	7.8mOD	7mOD

				FLOOD DEFENCE LEVEL		
Area	**Location**	**Channel**	**Chainage (m)**	**OPTION 1**	**OPTION 2**	**OPTION 3**
7A	Curragheen and Glasheen Rivers	Glasheen - Left bank	162 - 70.5	-	8mOD	7mOD
7A	Curragheen and Glasheen Rivers	Ashbrook Heights Culvert	170 - 162	-	8.1mOD	7mOD
7A	Curragheen and Glasheen Rivers	Glasheen - Left bank	215 - 170	-	8.5mOD	-
7A	Curragheen and Glasheen Rivers	Glasheen - Left bank	350 - 235	-	8.8mOD	7mOD
7A	Curragheen and Glasheen Rivers	Glasheen - Right bank	162 - 70.5	-	8.35mOD	7mOD
7A	Curragheen and Glasheen Rivers	Glasheen - Right bank	285 - 170	-	8.5mOD	7.8mOD

13 Economic Assessment of Shortlisted Options

13.1 Methodology

When building up cost estimates for a scheme of this nature, it is important that the expected whole life costs of the works and its management are developed and not just the scheme capital costs. The following list outlines the areas that were considered when developing cost estimates for this project:

- Construction costs.
- Design and site supervision costs.
- Site Investigation and survey costs.
- Environmental mitigation costs.
- Land purchase and compensation costs.
- Maintenance costs.
- Allowance for optimism bias and
- Allowance for Art.

The following costs were excluded:

- Value Added Tax and
- Cost of OPW/CCC staff time on the project.

13.1.1 Construction Costing Method

Base costs for construction elements of the scheme were obtained from the following sources:

- Estimates and tendered rates from similar civil engineering contracts and
- Published cost databases, including the NRA unit cost database and the draft OPW unit cost database.

The following assumptions have been made when compiling the construction cost estimates:

- Normal working week for construction personnel and plant and
- No exceptional adverse weather.
- Construction contracts with values of between €15m and €20m and durations of 18 to 24 months.
- Significant costs of traffic management within space restrictions in busy city environment.

- Allowance of 20% for known unmeasured items such as local drainage, services etc.

13.1.2 Environmental/Archaeological Monitoring, Mitigation Works and Improvement Works

Environmental and archaeological monitoring will be required during the construction of the works. It is also likely that some environmental mitigation and improvement works will be necessary. A provisional allowance of 10% of the construction cost estimate has been included in the cost estimate.

13.1.3 Site Investigation and other Surveys

A site investigation, topographic survey, archaeological survey and CCTV drainage survey will all need to be carried out for the scheme. The total cost of these investigations and surveys is estimated to be approximately €1,200,000 and has been included in the cost estimate.

13.1.4 Design and Site Supervision Costs

An allowance of 9% of the construction cost has been made for design and site supervision costs, reflecting the current best estimate of the likely duration of the construction contracts and required size of site supervision teams.

13.1.5 Land Purchase and Compensation

OPW have advised that 10% should be added to the construction cost of the scheme to allow for:

- Land purchases and compensation.
- Planning, highway and other third party costs.
- Administration and legal costs associated with land exchanges, statutory approvals, planning applications, service diversions, highway adoptions etc. and
- Loss of revenue to adjacent or affected buildings.

13.1.6 Maintenance Works Costs

The total maintenance cost over the 50 year life span of the scheme is estimated as 1% of the construction cost in Net Present Value terms.

13.1.7 Contingency/Optimism Bias

There can be a tendency for budget cost estimates for flood defence schemes to be overly optimistic. In a project of this nature where access for labour, plant and materials will be difficult, including a robust contingency in the cost estimate is essential.

A contingency/optimism bias of 20% of the construction cost has been included in the whole project cost.

13.1.8 Allowance for Art

The "per cent for art" scheme is compulsory for all major public works contracts. For this size of project, the required allowance for art is 1% of the capital cost up to a maximum of €64,000. Therefore the maximum allowance of €64,000 has been included in the cost estimate.

13.2 Summary of Costs for each Option

A full build-up of costs for each option is included in Appendix B. Table 16 below summarises the total costs for each option.

Table 16: Summary of Costs

	Option 1 – Flow Reduction in South Channel and Direct Defences	**Option 2 – Isolation of South Channel and Direct Defences**	**Option 3 – Direct Defences only**
	€	€	€
Measured Items	49,451,108	46,303,494	53,823,619
Prelims (17.5%)	8,653,944	8,103,111	9,419,133
Unmeasured Items (20%)	9,890,222	9,260,699	10,764,724
Subtotal	**67,995,274**	**63,667,304**	**74,007,476**
Archaeology & Environmental (10%)	6,799,527	6,366,730	7,400,748
Baseline Construction Cost Total	**74,794,801**	**70,034,035**	**81,408,224**
Contingency / Optimism Bias (20%)	14,958,960	14,006,807	16,281,645
Construction Cost Total	**89,753,761**	**84,040,842**	**97,689,868**
Fees and Supervision (9%)	8,077,839	7,563,676	8,792,088
Construction & Fees Total	**97,831,600**	**91,604,518**	**106,481,956**
Land Acquisition (10%)	8,975,376	8,404,084	9,768,987
Art (1% or Cap at €64,000)	64,000	64,000	64,000
Site Investigation & Surveys	1,200,000	1,200,000	1,200,000
Capital Cost Total	**108,070,976**	**101,272,602**	**117,514,943**
Maintenance Costs	19,279,108	18,051,973	20,983,784
Project Cost Total	**127,350,084**	**119,324,575**	**138,498,727**

14 Climate Change Adaptability

14.1 Introduction

In considering the merits of the potential options, it is important that the short term proposals are considered in the context of a longer term strategy which is flexible and adaptive to changes in the climate and its potential impact on flood risk. At present to test climate change adaptability, the OPW consider various potential future scenarios of change in extreme rainfall depths, flood flows, mean sea level rise, land movement (where applicable), urbanisation and afforestation. The Mid-Range Future Scenario for flow and tide is to test for a 20% increase in flow and 0.5m rise in mean sea level.

The Lower Lee has some undeveloped natural flood plain downstream of the Inniscarra Dam, however it is predominantly a constrained system in a heavily urbanised environment. This severely constrains the available options both in the short and the long term.

During the hydraulic modelling and assessment of measures (Section 4) it became clear that under the existing operating rules of the Inniscarra and Carrigadrohid dams, design flows at Cork City could be up to 860m^3/s.

Such peak design flows would require extensive replacement of bridge structures in combination with very high walls, which would render the solution unacceptable on a number of grounds including economic, environmental, heritage and social.

Therefore, it became clear that the implementation of optimised operating rules for Inniscarra and Carrigadrohid dams in combination with a suitable flood forecasting system, upland washlands and downstream protection measures are a pre-requisite to the development of a sustainable solution for Cork City.

All options considered therefore include the above measures.

Regardless of which option is adopted for the current scheme, the adaptations considered in terms of the long term strategy to manage climate change risk can be categorised as variations and combinations of the following approaches:

1. Measures to minimise flows downstream of Inniscarra
2. Tidal Defence Options
3. Adaptive direct defences
4. Additional direct defences on Curragheen and western part of South Channel
5. Other incidental measures

The adaptability of the scheme options is discussed in further detail in the following sections.

14.2 Measures to minimise peak flow downstream of Inniscarra

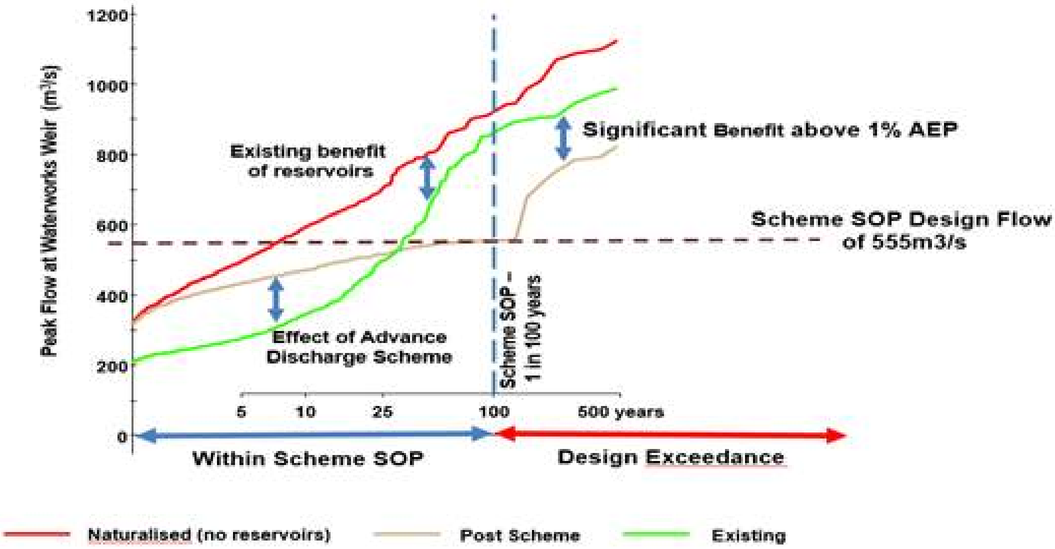
14.2.1 Quantified Testing of Potential Changes to the Dam Operating Procedures

There is a limitation in the volume that the reservoirs can attenuate when they are operated as per existing procedures and indeed when the proposed revised procedures are implemented.

The revised operating procedures proposed as part of the scheme have a significant benefit in reducing the peak flow for the design 1% AEP event from 860m^3/s to 555m^3/s as shown Figure 12.

However, as can be seen from Figure 55, there is a significant kick up in peak flow at circa the 130 year event, when the dam capacities under the proposed revised operating procedures is exceeded.

Figure 55: Change in Flood Frequency Curve



To test the climate change adaptability of the scheme, the impact of a 20% increase in the design inflow to the reservoirs (and on the downstream tributaries) was assessed assuming that the dam operating rules proposed for the current day design case were to be retained.

In this case, the resulting future case 1% AEP peak flow at Waterworks Weir increases to 793m^3/s, an increase of 42%.

This means that under the proposed rules, a 20% increase in inflow to the dams would result in a 42% increase in flow into the city, as the dam capacities are exceeded earlier, with dam safety rules requiring greater discharges. 793m^3/s is too high a flow to provide permanent direct defences for, within the city centre in particular. Although demountable defences could potentially be adopted in the future.

The predicted water levels from Waterworks Weir to Tivoli, arising from a 42% increase in flow at Waterworks Weir and 0.5m rise in sea level, increase by between 1.0m and 1.8m in the fluvial dominated areas and circa 0.5m in the tidally driven areas.

14.2.1.1 Alternative Scenario

Under the above climate change scenario, the design flow in the city is deemed too high to practically provide direct defences within the city centre.

Therefore, an alternative incorporating further changes to Carrigadrohid and Inniscarra dam operating procedures were investigated.

The proposed rules for the current scenario have been developed based on current constraints both in terms of dam operation and the proposed flood forecasting system. However, in the future, it is possible that some of these constraints could be lessened.

Scenario B was considered with the following alterations relative to the original Scenario A:

Allowing earlier and larger releases on the run up to and during an event to reduce the starting level in the dam to the minimum operating level and to preserve storage during the flood. (Proposed scheme currently assumes staged increases in discharge to minimise impact of false alarms.)

The results of the analysis of the above alternative delivers a 100-year flow (in the climate change scenario) of 618m^3/s at Waterworks Weir. This represents an 11% increase in the design flow, which can be more reasonably be dealt with by extension of downstream direct defences.

14.2.2 Qualitative Assessment of other potential alterations to dam operation which would further mitigate the impact of climate change on peak flows into Cork City

The revised operating procedures proposed as part of the scheme are constrained by a number of factors which could change in the future as follows:

- Forecast system takes account of limitations of forecast accuracy and a short term historic dataset.
- Minimal levels in the dams are limited by factors such as water supply, top sluices at Inniscarra and environmental issues at the Gearagh.
- Maximum discharges from Inniscarra are limited by the capacity of the top sluices, including head limitations.
- Maximum discharges from Inniscarra are limited by max discharge which will not flood downstream, adopting a potentially conservative assumption on tidal levels (due to limited data at present).
- Spillway in Carrigadrohid increases spill rates when spillway level is reached.
- Dams continue to operate as hydroelectric dams in normal time.

- Availability to discharge through the turbines or the scour valve at Inniscarra cannot be guaranteed.
- Limitation on drawdown rate at Carrigadrohid due to potential impact on road retaining structures.

Whilst the above constraints now apply, it is possible that in the future, some or all of these constraints could be less onerous and could therefore allow even greater attenuation to be achieved. These are discussed further in a qualitative way below:

14.2.2.1 Improvement in Rainfall/Flood Forecasting

The proposed revised dam operation procedures have been developed on the basis of the quality and nature of current rainfall forecasting technologies, forecast resolutions, and based on a short historic record.

In the future, it is likely that there will be advances in technology which will result in improvements to the accuracy and reliability of the flood forecasting system, and at longer lead times, thus reducing the uncertainties associated with it.

This could provide greater ability to manage discharges in the lead up to and during a flood event.

14.2.2.2 Minimum Dam Levels and Increased Useable Storage

The proposed operating rules to be implemented as part of the proposed scheme have by necessity adopted a conservative assumption on dam starting levels.

This is driven by the dam’s normal use as a hydroelectric dam, as well as other restrictions such as the existing water supply extraction level.

Some but not all of these are considered in the scenario tested above. However, in the future, it may be possible to further lower minimum dam starting levels prior to an event. This would be achieved through a combination of some or all of the following:

- Improvements in forecast lead times allowing dam levels to be lowered further in advance (see above)
- Physical alterations to the Dams (see below)
- Changing the primacy of dam use. At present, it is a hydroelectric dam. Under the proposed scheme, its primacy will be as a hydroelectric dam with a secondary flood risk management. In the future it could be used primarily a flood risk management dam. However, it is envisaged that such a change would not yield significant additional benefit.

14.2.2.3 Further Amendment to Dam Operating Procedures including Consideration of the Tidal Cycle

In the proposed scheme, the dam operating procedures to be adopted during a fluvial flood event have been developed to allow operation in a simplified pre-determined approach.

This is a low risk and thus conservative approach which allows for straightforward decision making, i.e. scenarios in bands/ranges, adopting simplified and conservative assumptions about certain parameters. Such a system reduces the reliance on human decision making in the pressurised environment of an extreme event, and hence the risk of human error.

However, as every event is different, with advances in systems and greater familiarity of users, it is possible for the system in the future to move towards a more complex, dynamic and less conservative system which would allow more extreme events to be dealt with but which would place a much greater emphasis on professional operators/decision makers and so would have an increased risk of human error. However, such a change in approach would need to be carefully considered as the consequences of human error would be very significant.

It is feasible that a more deliberate operation could be implemented with dam discharges more frequently being regulated and timed around the tidal cycle, where possible, with little or no discharges at the peak of the tide, balanced by increased discharges when tide levels are lower. Similar, if a tidal barrage solution were to be implemented in the future, as described below, dam discharges could be restricted during periods when the tidal barrage is closed.

This change in regime would assist in limiting the potential impacts of climate change. However, it would increase the risk of human error.

14.2.2.4 Physical Alterations to the Dams

Inniscarra Dam discharges are currently physically constrained by available head at the top sluices, which limits the maximum advance discharges ahead of a flood event and sets a floor on the starting dam level.

Although it would be a major engineering project, and would require significant study and assessment in terms of the potential to do so, it may be possible to undertake retrofit measures which would allow levels to be drawn down faster and to a lower level ahead of a major flood event and thus create additional storage. These could take the form of either:

- Retrofitted low level sluices
- High capacity siphons
- A spillway tunnel through the rock on the right bank.
- Replacement of some blocks at the right flank of the dam by a gated concrete-lined spillway

All of these options would be technically challenging, would require extensive investigation of the existing dam structures, would be extremely expensive, and would need careful consideration in terms of dam safety.

Another possible option is to increase the reservoir capacity by raising the crests of the dams. Again there would be significant dam safety implications and costs involved in such a scenario.

Again, in the presence of viable alternatives, it has been recognised that measures requiring physical alterations to the dams should not be investigated at present. However, these options may become viable in the future.

14.2.2.5 Change of Dam Use

Currently, the primary use of the dams is for the generation of hydroelectric power.

Therefore the ongoing cost of maintaining the dams in operational mode is a cost of the hydroelectric operation and covered by revenues generated by the hydroelectric scheme.

At present, this income is essential to allow the dams to be available for use for flood risk management. At present, it would not be cost beneficial for the Scheme to operate the dams for flood risk management purposes only.

However if climate change was to exceed the MRFS, the cost of expected damages to property would become even more substantial.

In such a scenario, it may become viable to change the function of the dams to primarily one of flood risk management. However, it is considered that the additional benefit in such a change would be small.

14.2.3 Conclusions of minimising peak flow

It is evident that significant investment and work would be needed to establish if some or all of the above can significantly mitigate the potential impacts of climate change. However, the above illustrates that there remain a number of options which could be considered in terms of climate change adaptation with respect to minimising increases in peak flows reaching Cork City. Notwithstanding this, it appears likely that if increases in flow of 20% or greater occur, it is unlikely that this increase could be dealt with entirely by further modifications to the dams, dam operating procedures and/or flood forecasting system, and therefore it is prudent to design downstream direct defences to be capable of future raising to a practical degree in the scenario where greater flows need to be catered for.

14.3 Tidal Protection

With climate change and associated sea level rise, frequency of tidal flooding will likely increase, with an associated increase in the cost of damages.

The following sections set out the proposed strategy to deal with sea level rise.

14.3.1 Tidal Defence Walls in the City

In the eastern reaches of the city, the majority of direct defences are only 0.6m high or less. There heights are driven by tidally dominant events. Therefore, subject to suitable public realm design, the logical, least expensive and most environmentally sensitive means of dealing with the Mid-Range Future Scenario (MFRS) increase of 0.5m is sea level would be to increase the height of these defences.

For this reason, these defences will be designed for potential future raising to a permanent height of 1.2m to allow for an increase in tidal protection. As discussed earlier, it is considered likely that in future, dam discharges could be limited or avoided during the tidal peaks, thus minimising the hydraulic gradient across the city during extreme tides and therefore minimising the required defence heights.

In many areas, the scheme flood defence walls are proposed to heights which are near or at their practical or physical limit and cannot sensibly or practically be extended on a permanent basis.

In the current scheme, flood gates have been kept to an absolute minimum due to the residual risk associated with the need for their operation during an event and the insurance industry’s current reluctance to provide insurance in areas protected by flood gates or demountable defences. However in the future, should significant increases in sea level arise, it is likely that demountable defences may become a more viable option along greater lengths of the city quays.

For example, at Grenville Place, road regarding forms part of the proposed scheme so that the relative defence wall height is limited to guarding height of 1.2m. Given the proximity of the Mercy Hospital as well as heritage structures like Boole House, there is little opportunity to further alter ground levels in the future and therefore further raising of wall heights above guarding height would impact the connection with the river. In this scenario, demountable defences may well be an acceptable solution. For this reason, it is proposed that all new defence walls within the fluvially dominated reach will be designed to be able to be extendable in the future to resist a total hydrostatic load of 2.2m above dry side ground level. (In practice, this would likely be a 1.2m high permanent defence wall supporting a further 1m height in demountable defences).

14.3.2 Tidal Barrier

Tidal barriers were assessed for the current scenario as part of the Lee CFRAMS at a number of locations in Cork Harbour. This assessment was reviewed as part of this study as discussed in Section 4.2.4.4 above. Tidal barriers were found not to be economically viable under existing conditions at any of the potentially technically viable locations.

It is considered unlikely that this would change under the MRFS (and significantly beyond) where the climate change adaptation strategy for tidal defences in the city will likely be adaptation of the proposed direct defences. However, if mean sea level rise were to approach or exceed 1m, it may become feasible that a tidal barrier in Cork Harbour could become economically viable.

The most likely potential location for a tidal barrage would be in the lower harbour to the west and east of Great Island. They would potentially be located between Monkstown / Passage and Great Island to the west, and Great Island and East Ferry to the east.

This option was tested for both the MRFS and HEFS as part of the Lee CFRAM Study.

The Lee CFRAMS concluded that with a mean sea level increase of 1m and a 30% increase in inflows, a typical daily tidal peak of circa 2.8mOD would occur in Cork City. Extensive flooding of Cork City occurs at 2.8mOD (similar to 2014 flood event). This would therefore mean that in the absence of direct defences, the tidal barrier may need to be closed several times a week. It estimated that the closure time would need to be somewhere between 5 and 9 hours per tidal cycle, (or between 10 and 18 hours per day). Such a scenario, would fundamentally alter the use of the harbour in terms of both shipping and use of pleasure crafts. It is also likely to have very significant effects on the SAC and SPA designated areas in Cork Harbour, including effects on harbour flows and velocities, sediment transport and salinity.

Based on the above, it is considered likely that in the HEFS, a tidal barrage could only work in tandem with direct defences in the city which would have the benefit of reducing the frequency and duration of required closure of the barrier.

It is therefore evident that the construction of direct (and adaptable) tidal defences in the eastern part of the city is both the correct solution in the short term as it provides the required standard of protection in a sustainable and cost beneficial way, but would also form an essential part of the longer term climate change adaptation strategy.

14.4 Adaptive Approach for Direct Defences

The adaptive approach allows for flood defence walls to be designed so that they can be extended in the future to take account of the potential effects of climate change. It does require additional investment at the beginning of the scheme in the construction of the foundations of the walls, however it provides some flexibility in the future to economically extend the standard of protection (with minimum disruption) as the impacts of climate change are felt.

In this flood relief scheme, it is considered appropriate to take an adaptive approach for the direct defences to manage the climate change risk, either by allowing for a permanent increase in wall height in some areas and/or the potential future installation of demountable defences in other areas, as discussed above.

14.5 Additional Direct Defences

If the preferred option is selected, no defences will be required in the short term on the Curragheen or western section of the south channel as flow in the South Channel is restricted by the construction and use of the flow control structure at the head of the South Channel.

However, in the future, defences could be constructed on these reaches to increase the capacity of the South Channel. This would allow it to take a greater proportion of the flow from the Lee. Whilst no physical works are required to facilitate this adaptation option, it is prudent to consider the potential for increasing the capacity of the south channel in terms of development and planning control and in consideration for section 50 requirements for any potential future bridges.

14.6 Other Incidental Measures

There a number of other measures which could contribute to managing the climate change risk. These are summarised below:

- Hydrometric/Meteorological Data Collection/Joint Probability

In the coming period, additional data will be collected which will assist in developing our understanding of the hydrology of the catchment and in particular, the joint probability of fluvial and tidal events. The current Joint probability analysis is by necessity, conservative at present, due to limited data available. In addition, calibration data for significant combined river flow and tidal events is limited. This means that reasonable allowances are contained within defence heights for freeboard to cater for hydrological and hydraulic uncertainty. Greater data could allow greater certainty in predicted flood levels and thus reduce freeboard requirements which would have the effect of minimising the requirement to raise defence heights in the future.

- Replacement of bridges with insufficient hydraulic capacity

When bridges reach the end of their design life and are to be replaced on the Lower Lee in the future, the design water levels should be considered and soffit level raised to a sufficient level so as to allow unrestricted flow. This will be particularly important on the North Channel.

14.7 Summary of Recommended Approach

The OPW has defined a number of approaches to managing climate change risks. The best approach to adopt is largely driven by the potential increase in flood risk which will be experienced over time, but would also consider the practicalities associated with taking a particular course of action now, or delaying it until the future.

An ‘Assumptive approach’ could be adopted (and has traditionally been adopted) where one assumes that a certain degree of impacts arising from climate change will occur. This means the scheme would be designed and built (or at least foundations built) now to the levels estimated for the future. Although providing a degree of certainty in protection, the levels are reliant on today's estimates of climate change impacts (i.e. the anticipated increases in river flows) being correct. If the estimates are too high, the scheme would be built to a greater than necessary level, which could be visually intrusive and incur a high level of additional expenditure. Consequently, this has a negative impact on the cost benefit analysis and Multi-criteria analysis for the scheme (higher costs and reduced visual and environmental benefits) making the scheme less likely to be beneficial. Alternatively, the estimates of climate change impacts may be too low, and river flows increase to a higher than anticipated level over a shorter than planned timeframe. This means the scheme would still not be sufficient to defend against the climate change levels and would still need to be reviewed in the future.

An alternative, and now more common approach is to adopt an ‘adaptive approach’ which provides a greater level of flexibility into the future, allowing the scheme to be adapted as estimates improve, or increased evidence of climate change emerges.

Planning to increase defences in the future would require additional investment in the foundations of the scheme, but would allow easier 'up-build' in the future. The works to build the new, or in-fill, walls and embankments highlighted above would still be required in the future, but more certainty on the location and heights of these assets would develop over time. However, the scheme now would need to be designed to allow future construction to tie in to the current scheme.

In advance of undertaking adaptive works, the design of the scheme would allow some take up of the water level increases through the freeboard allowances. The freeboard is based on uncertainties derived from the modelling, and it is possible that as a better understanding of the hydrological record develops (i.e. as the record gets longer and more flood events are experienced) the modelling uncertainty will reduce, thereby warranting a reduced freeboard. The reduction in required freeboard could balance the increase in water levels due to climate change.

In some instances, it may be justifiable to design and build the scheme with no adaptability for the future. This would see the walls and embankments implemented as designed. Whilst this avoids the initial increased costs in foundations, there is no scope for adaptability over time.

In the case of the Lower Lee Scheme, it is recommended that a combination of the approaches outlined above be considered and implemented to manage the climate change risk and provide for a scheme that is adaptable to future conditions, including:

- Minimise increases in flow arising from climate change by further changes to the dam operation and/or improvement in forecasting
- Dynamic management of discharges offset from the tidal peak
- Adaptive direct defences, as described below
- Tidal barrier, only as a long term option, should sea level rise to around the HEFS of circa 4mOD subject to it becoming cost beneficial at the time.

In terms of adaptability of the direct defence elements to be constructed as part of the proposed scheme, the following is proposed:

- Direct defences between Inniscarra Dam and St.Vincent's Bridge to be designed to be adaptable for a future 1m increase in levels.
- Direct Defences in the tidally dominated city centre areas to be adaptable to be raised to a permanent defence height of 1.2mOD above dry side ground level or 4mOD.

15 Environmental Assessment of Shortlisted Options

An Environmental Assessment of the shortlisted options was undertaken by the Project Environmental Consultants and is reported on separately in the Environmental Impact Statement.

The findings of environmental assessment were incorporated into the scoring of the relevant sections of the Multi Criteria Analysis which is summarised in the following section of this report.

16 Multi Criteria Assessment of the Shortlisted Options

16.1 Introduction

The effectiveness of each of the viable options can be measured in terms of how it achieves a set of flood risk management objectives. This section describes the detailed multi-criteria analysis (MCA) of the shortlisted options which was carried out to evaluate the performance of each option in terms of predefined objectives.

As part of this process, each objective was given a global and local weighting. Each option was then scored relative to the present day situation (baseline condition), based on how well they met the objectives. The output from this stage was a total weighted score for each option. The option with the highest score is deemed to most desirable.

As discussed in the previous chapters, the implementation of optimised operating rules of the Inniscarra and Carrigadrohid dams in combination with a suitable flood forecasting system and upland washlands are prerequisite measures to the development of a sustainable solution for Cork City. Therefore these measures are common to all options and will not be considered in this assessment. This assessment will only consider where there are differences between the options.

16.2 Flood Risk Management Objectives and Weightings

The flood risk management objectives were categorised as follows:

- Technical
- Economic
- Social
- Environmental

The categories were sub-divided into objectives (see Table 17). Each objective was weighted to reflect their importance and/or sensitivity, and to ensure that the objectives most relevant to the location under consideration were given priority in the decision-making process.

Two types of weighting were used:

- Global weighting (ranging between 5 and 30) which applied a weighting, fixed by the OPW at a national level, to each objective used. The global weightings are shown in Table 17.
- Local weighting (ranging between 0 and 5) which was specific to the importance of each objective in the location where the option was being considered. The local weightings are shown in Table 18.

Table 17: Flood Risk Management Objectives and Global Weightings

Category	Objective	Global Weighting
Technical	Operationally Robust	20
Technical	Minimise Health & Safety Risk	20
Technical	Adaptability	20
Economic	Economic Return	30
Economic	Transport Infrastructure	10
Economic	Utility Infrastructure	10
Economic	Agriculture	10
Social	Risk to Human Health	40
Social	Community Risk	15
Social	Risk to Social Amenity	5
Environmental	Water Framework Directive Objectives	15
Environmental	Habitats and Birds Directives Objectives	15
Environmental	Flora and Fauna	5
Environmental	Fisheries	5
Environmental	Landscape Character	10
Environmental	Cultural Heritage	10

Table 18: Local Weightings

Importance	Local Weighting
Major / International importance	5
Significant / National importance	4
Medium / Regional importance	3
Minor / Local importance	2
Negligible importance	1
Not relevant	0

16.3 Scoring

Each option was then scored relative to the present day situation (baseline condition), based on how well they met the objectives. The scores used ranged between -999 and 5 as shown in Table 19.

Table 19: Scoring System

Impact	Score
Achieving aspirational target	5
Partly achieving aspirational target	3
Exceeding minimum target	1
Meeting minimum target	0

Impact	Score
Just failing minimum target	-1
Partly failing minimum target	-3
Fully failing minimum target	-999
Uncertain	N/A

A description of the minimum targets and aspirational targets for each objective are included in Appendix C.

16.4 MCA Assessment

A total weighted score was then calculated for each objective as the sum of the weighted scores across the 15 flood risk management objectives. This MCA score reflected the performance of the option in terms of the study's objectives.

The weighted score was calculated as follows:

WS = (GW x LW) x S

Where:

- WS = Weighted Score
- GW = Global Weighting
- LW = Local Weighting
- S = Score

The total MCA score was the sum of the scores for each objective.

The detailed MCA assessment is included in Appendix C.

16.5 Summary

Table 20 below presents the results of the MCA analysis.

Table 20: MCA Results

	Option 1 – Flow Reduction in South Channel and Direct Defences	**Option 2 – Isolation of South Channel and Direct Defences**	**Option 3 – Direct Defences only**
MCA Benefit Score	2215	1635	1960
Option Selection Benefit Score*	2715	1735	2660
NPV Capital Costs (€m)	90	84	98
MCA Benefit/Cost Ratio	0.025	0.019	0.020

*Note: The Options Selection Score excludes the score for the Technical Criteria

The analysis suggests that Option 1 is the most favourable in terms of MCA benefit/cost ratios, MCA Benefit Score and Option Selection Benefit Score.

There is no difference in the economic and social scoring, as all options provide protection to the same standard with no significant residual risk to humans, economy or infrastructure.

Option 2 scores significantly lower in the technical criteria, mainly in terms of the operational robustness measure, as this option relies heavily on implementation of four inter-related flow regulation structures on the South Channel and Curragheen. Timing of closure of structures is important, resulting in a complex operational scheme.

Option 2 and 3 score lower in the environmental criteria mainly due to the aesthetics of visually intrusive high walls in the Curragheen area. Option 2 also has significant in-stream works which would have a greater negative environmental impact than the other two options.

Full details of the individual scores for each criteria for each option, together with the rationale for same, is included in Appendix C.

17 Selection of Preferred Option

The extent and severity of the flood risk in the study area was first established through a hydrology study, hydraulic modelling, flood mapping etc.

Early in the project, it was agreed with OPW, that the design standard of protection (SOP) for the Scheme would be the 1% AEP Fluvial/0.5% AEP Tidal. This is a recognised standard internationally, and is the standard adopted nationally on the majority of OPW schemes. It is also the standard generally being requested by the Insurance Industry.

It was also a requirement of the scheme that the extent of flood gates required be minimised to make the scheme as passive as possible, i.e. requiring least human intervention during a flood event.

The benefits of defending to the design standard of 1% AEP Fluvial/0.5% AEP tidal was then established to inform a detailed cost benefit analysis.

The findings of the Lee CFRAM Study recommended an option of Optimised Dam Operations in conjunction with a suitable flood forecasting system, and direct defences.

From our initial hydrological and hydraulic assessment, it quickly became apparent that the existing case 1% AEP flow of circa $860m^3/s$ could not be safely conveyed through Cork City without the need for unacceptably high defences which would destroy the character of the city and the relationship of the city with the river.

Therefore, a pre-requisite to developing a direct defence scheme through Cork was to reduce the peak flow for the design 1% AEP event through the use of revised dam operation procedures in conjunction with a flood forecasting system based on predicted rainfall at long lead times. Details of the Revised Dam Operation Procedures and Flood Forecasting System are outlined in Sections 6 and 7 of this Report. This element has the beneficial effect of reducing the design flow reaching the city to $555m^3/s$.

Once the revised design flow was established, it was then necessary to establish the extent and nature of defences required downstream of Inniscarra dam through to Custom House.

A range of potential flood risk management measures were reviewed as part of an initial screening exercise.

Whilst some potential conveyance improvements were assessed to the west of Cork City, these had marginal benefit in reducing flood levels and therefore direct defences to contain the design flow was the only viable measure taken forward to Options Selection Stage in this reach.

In terms of the downstream tidal boundary, both the Lee CFRAMS and this study confirmed that a Tidal Barrage is not currently a cost beneficial option. Therefore, the design tide must be defended against within Cork City.

Following initial review, it was concluded that whilst there were some areas at risk of tidal flooding in the north and south docklands areas, there wasn't a cost beneficial scheme in these areas and flood risk in these reaches would be addressed through planning control as the expected redevelopment of these areas occurs over the coming years.

Therefore, the consideration of potential alternative options was limited to the city reach from Inchaggagin to Custom House. Alternatives in this reach focussed on the split of flow between the North and South Channel, the impact of the Curragheen flows on levels in the South Channel and the potential to minimise defences on the South Channel and Curragheen by limiting inflows into the South Channel, from river flow and/or from the tide. The options were also informed from feedback from the significant Public Consultations that took place during Stage 1 of the project.

Following a review of the potential viable measures, 3 potentially viable options were developed to outline design level and can be summarised as follows:

- Option 1 – Direct Defences with Flow Reduction on South Channel (only tidal defences on South Channel)
- Option 2 - Direct Defences on North Channel only (with temporary isolation of South Channel in tidal event)
- Option 3 - Direct Defences throughout (no alteration to flow split between North and South Channels)

These options are described in detail in this report.

All three options were then developed to outline design level including hydraulic modelling, outline design and costings.

A final decision on the preferred option was made based on a holistic evaluation of the following key aspects:

- Relative cost of each Option
- Findings of Multi-Criteria Analysis
- Consideration of the key core messages which arose during the stakeholder consultation process
- Consideration of Key Risks
- Consideration of Climate Change Adaptability
- Combined professional judgement of the steering group members

The following sections summarise the critical issues with each potential option, along with reasons for ruling the options out where relevant.

(Note: All options require revised dam operation rules and flood forecasting system to be implemented.)

17.1 Option 3 – Direct Defences Throughout

This option comprises direct defences only and does not consider flow management measures within the South Channel.

The relative advantages of this option versus the other options are as follows:

- Fluvially dominated defence heights on the North Channel (between Salmon Weir and North Main Street) are up to 400mm lower than the other options.
- Most passive solution, i.e. no flow control structures needed.

The relative disadvantages are as follows:

- Significant additional lengths of defences (and heights of defences) needed on Curragheen (from Model Farm Road) and western (fluvially dominated) reach of the South Channel.
- Most expensive of all options.
- Involves defences on greatest length of channel and therefore is least easily adapted for climate change.

This option had the best MCA score in terms of technical robustness, due to its passive nature. However, it had a significantly lower MCA environmental score due to the visually intrusive scale and extent of defences on the South Channel and Curragheen, and the length of channel affected.

Overall, it scored second of the three options on both MCA score and options selection score. It was joint second (with Option 2) on MCA Benefit/Cost Ratio as its relative merits over Option 2 was negated by its higher cost.

17.2 Option 1 - Direct Defences with Flow Reduction on South Channel

This option comprises slightly higher defences on the fluvially dominated reach of the North Channel, defences on the tidally dominated reach of the south channel only, no defences on Curragheen or fluvially dominated reach of south channel and a new flow regulation structure at the head of the south channel.

The relative advantages of this option versus the other options are as follows:

- No defences required on the Curragheen or fluvially dominated reach of South Channel.
- Less expensive than the option of direct defences throughout.
- Relatively straightforward operation of a single flow regulation structure versus the more complex arrangement of 4 such structures for Option 2.
- Least intrusive scheme from a visual perspective and effects least amount of channel.
- Most adaptable scheme from a climate change perspective.

The relative disadvantages are as follows:

- Fluvially dominated defence heights on the North Channel (between Salmon Weir and North Main Street) are up to 400mm higher than the option of direct defences throughout, (similar heights to Option 2).
- More expensive than Option 2.
- Requires intervention to regulate flows on South Channel (although will be automated).

This option had the best MCA score, options selection score and MCA Benefit/Cost Ratio.

17.3 Option 2 - Direct Defences on North Channel only

This option is an extension of Option 1. Fluvially dominated events would be managed similarly to Option 1, through use of the flow regulation structure at the head of the south channel.

The key difference is that rather than defending the South Channel from tidally dominated events, the South Channel would be isolated during tidal events, with tidal inflow prevented by closure of a downstream control structure at Custom House.

To operate this solution, additional flow regulation structures would be required on the Curragheen/Glasheen to divert the flow from these watercourses into the North Channel, (as the isolated South Channel could not accommodate the scale of flow from these watercourses).

The relative advantages of this option versus the other options are as follows:

- Least expensive of all options.
- No defences required on any of South Channel.

The relative disadvantages are as follows:

- Least technically robust, with most complex operation for multiple permutations for 4 flow regulation structures in multiple scenarios.
- Significant environmental impacts arising from temporary diversions of Curragheen and Glasheen.
- Significant additional lengths of defences (and heights of defences) needed on Curragheen.
- Fluvially dominated defence heights on the North Channel (between Salmon Weir and North Main Street) are up to 400mm higher than the option of direct defences throughout, (similar heights to Option 1).
- Least adaptable for climate change as required levels of defences on Curragheen would be at practical limit, and with limited options to deal with increase flows on Curragheen.

This option had the worst MCA score, options selection score and MCA Benefit/Cost Ratio.

17.4 Selection of Option 1 as Preferred Option

Option 1 was selected as the preferred option for the following reasons:

- It had the best scores in terms of all three of MCA score, options selection score and MCA Benefit/Cost Ratio.
- Less expensive than the option of direct defences throughout (which otherwise would be next most preferable option).
- It requires work on the shortest length of channel (and therefore least disruption and environmental impact).
- No defences required on the Curragheen or fluvially dominated reach of South Channel.
- Least intrusive scheme from a visual perspective and effects least amount of channel.
- Relatively straightforward automated operation of a single flow regulation structure.
- Most adaptable scheme from a climate change perspective.
- Offers greater flexibility in terms of managing different events than the direct defence only option where flow split at Salmon Weir cannot be altered.
- The additional 400m in height of defences required on the fluvially dominated reach of the North Channel is not considered to materially alter the nature or impact of the scheme defences in this reach.
- This option was presented to the public as the emerging preferred option and was generally met with a positive response.

A decision on the preferred option was ultimately made by careful and holistic professional consideration of all of the various issues, resulting in Option 1 being chosen.

Option 1 was then subjected to a detailed cost benefit analysis, including sensitivity test, which illustrated that this option had a strong cost benefit ratio.

18 Cost Benefit Analysis of Preferred Scheme

18.1 Cost Assessment

Refer to Section 13 above for details of the cost assessment.

Table 21 below provides a summary of the costs of the preferred scheme.

Table 21: Summary of Costs

	Option 1 – Flow Reduction in South Channel and Direct Defences
	€
Measured Items	49,451,108
Prelims (17.5%)	8,653,944
Unmeasured Items (20%)	9,890,222
Subtotal	**67,995,274**
Archaeology & Environmental (10%)	6,799,527
Baseline Construction Cost Total	**74,794,801**
Contingency / Optimism Bias (20%)	14,958,960
Construction Cost Total	**89,753,761**
Fees and Supervision (9%)	8,077,839
Construction & Fees Total	97,831,600
Land Acquisition (10%)	8,975,376
Art (1% or Cap at €64,000)	64,000
Site Investigation & Surveys	1,200,000
Capital Cost Total	**108,070,976**
Maintenance Costs	19,279,108
Project Cost Total	**127,350,084**

18.2 Damages Assessment

18.2.1 Overview

The benefit to be derived from the flood protection works is the reduction in risk of flooding to land and property. This risk is quantified as the expected damage to property that would occur over the lifetime of the scheme.

The adopted approach assesses the damages for the Lower Lee Study area as a whole. It is recognised that individual properties and areas may have a positive or negative impact on the overall scheme based on their individual valuation of benefit and the cost. These differences are spread across the scheme to give a comprehensive assessment.

The damages assessment has not made allowance for the additional depths of flooding caused by climate change, whilst climate change provision has been included in the scheme where feasible. This introduces an element of conservatism into the cost benefit analysis.

18.2.2 Guidance

The analysis has been carried out in accordance with the OPW guidance document "Lower Lee, Douglas and Glashaboy Flood Relief Schemes: Economic Damage Assessment and Cost Benefit Analysis (Rev B)". This guidance document sets out a common approach to the calculation of monetised economic flood damages and the economic benefits of flood risk management options, and for undertaking a cost-benefit analysis.

Flood damage data has been assessed from the "The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques (2014)" published by the Flood Hazards Research Centre at Middlesex University. This document is often referred to as the "Multicoloured Manual" (MCM).

The calculation of flood damage for both residential and commercial properties can be classified into two broad categories, namely tangible damages and intangible damages, both of which are described in the following sub-sections.

18.2.3 Direct Tangible Damages

These can be quantified in monetary terms, such as the reduction in flood damage costs from improvements in the standards of flood protection. Tangible damages are divided into the direct and indirect.

Direct tangible damages result from the physical contact of flood water with property. The damage magnitude may be taken as the cost of the property restoration to its condition prior the flood event, or its loss in market value if restoration is not worthwhile. Direct damages are a function of many variables including the physical make-up of the property and the characteristics of the flood event, including the depth and duration of flooding.

The unit damages for non-residential properties has used the MCM "initial appraisal" approach. This is because the MCM 2014 "full-scale appraisal" only includes damages broken down by social class. As per OPW guidance, social class is to be excluded from damages assessment for this project.

18.2.4 Indirect Tangible Damages

Indirect tangible damages are losses caused by disruption of physical and economic linkages to the local/national economy. Examples include the costs of emergency services of a flood event, and the interruption of traffic flows.

MCM 2014 estimates the cost of emergency services as between 5.6% and 10.7% of the direct tangible damages (direct tangible damages are referred to as the "Principal Direct Damages" (PDD) in the OPW guidance note).

OPW guidance directs that an allowance of 8.1% of the PDD be included in the damages assessment to account for emergency services. OPW guidance states that this allowance is deemed to include evacuation costs.

An allowance of 20% of the PDD has been included to account for damage to infrastructural utility assets as per OPW guidance.

The cost of traffic disruption is more difficult to determine as it is a function the volume of traffic disrupted by a flood event, availability of alternative routes for disrupted traffic, the volume of traffic already on alternative routes as well as the duration and extent of a flood event. MCM 2014 notes that traffic disruption damages for previous flood events in the UK has varied between 2% and 10% of the direct tangible damages.

Given the significant disruption to traffic that occurred during previous flood events in Cork City, we have accounted for damages due to traffic in our analysis through an allowance of 5% of the PDD.

As per OPW guidance, damage to roads, damage to parked cars, environmental damage, personal evacuation costs, temporary accommodation and extra heating costs have been ignored in our assessment.

Flood events are typically associated with loss of revenue to businesses. We have not included business losses in our baseline damages scenario but have considered it as part of our sensitivity analysis as detailed in Section 18.3.3.

The damage costs associated with risk to life have been excluded as per OPW guidance. This has been excluded, as loss of life due to flood events is very rare in Ireland.

18.2.5 Intangible Damages

These are difficult to quantify in monetary terms as they include human stress and anxiety, inconvenience and ill health associated with frequent, repeat flooding.

In accordance with typical OPW practice, the flood damage assessment undertaken for the scheme has used the PDD as a guide to estimating the Intangible Damages. The guidance distinguishes between residential and non-residential properties;

- For residential properties, the intangible flood damages are set equal to the total direct property damage as per OPW guidance.
- For commercial properties, we have set the intangible flood damages equal to the total direct property damage for all businesses that are assumed to be family owned in the study area. This is in keeping with OPW guidance which notes that intangible damages should be applied to individually or family-owned businesses where the intangible impact would be personal and similar in nature to what might be experienced were the property residential.

As part of our assessment we identified all the family-owned commercial businesses within the 20 year tidal flood extent and compared them against the non-family owned commercial businesses within the same extent.

It was found from the analysis that the floor area of the property acts as a very good identifier as to whether the commercial property is family owned or not as family owned properties tend to fall below a certain threshold in area. By summing the area of all the family owned commercial businesses and comparing it against the sum of all the commercial business it was found that that approximately 20% of the total area of all the commercial properties are family owned businesses.

Using this percentage, the commercial intangible damage has therefore been set equal to 20% of the PDD for commercial property across the study area.

18.2.6 Fluvial and Tidal Damages

Based on the historic record of flooding in Cork City, fluvial and tidal flooding are considered to be independent mechanisms. The damages for both fluvial and tidal events have therefore been added together to give the total damage for each property. To avoid overestimation of damages however, the hydraulic models that generated the design water levels for the damage analysis were run with conservative boundary conditions:

- The fluvially dominant design runs were run with a T1 design tide as the downstream boundary condition.
- The tidally dominant design runs were run with a Q2 design inflow as the upstream boundary condition.

This conservatism ensures that the damage calculated for the fluvial dominated events is attributed to fluvial flooding i.e. the tidal component of the fluvial dominated events is negligible. It also ensures the same conservatism is applied to the tidal flooding i.e. the fluvial component of the tidal dominated events is negligible.

It was ensured in our analysis that the combined damage for each property did not exceed the capping value for the property.

18.2.7 Thresholds of Flooding

The threshold of flooding is the level at which flooding of the property will start to occur. For this scheme, the threshold of flooding for each property is determined based on the hydraulic model results and the surveyed/assumed floor level for each property.

We have used the threshold survey undertaken as part of the Lee CFRAM Study to set the ground levels of all the significant properties in the City. This data has been supplemented with additional ground floor levels where available.

Where no threshold survey information was available, it was assumed that the ground floor level of each property is 150mm above the Lidar ground level. This is thought to be conservative for the city centre area where many floor levels are at a similar level to outside ground level, although there are some notable exceptions.

18.2.8 Damage Assessment GIS Tool

Arup has developed an in-house GIS tool which was used to support the calculation of flood damages for the study area. The tool creates a single dataset of all residential and commercial properties in the study area and estimates the flood depths for the various return periods at each property using the hydraulic model results. The tool then assigns flood damages to each property using the flood damage data in the MCM.

The datasets used by the tool are:

- Geodirectory dataset – for determining the building type and use. In Geodirectory, the economic activity associated with each property is held as a NACE code (Nomenclature of Economic Activities). NACE is the European statistical classification of economic activities. Where discrepancies were found, the properties were inspected on site or through use of "street view" imagery freely available online.
- OSi NTF dataset – for calculating the area of the commercial properties;
- 2D hydraulic modelling results – water levels to OD Malin for eight separate return period events are used by the tool to determine the extent and level of flooding in throughout the study area. Subtraction of the property threshold level from the water level yields the depth of flooding at each property for all the return period events.
- Lidar data – for estimating the ground level of all the properties in the Study area for which no property threshold survey information was available. It has been assumed that the threshold level of all the properties is 150mm above the Lidar ground level.
- It was noted that some discrepancies exist between the Geodirectory and NTF datasets.

The FHRC damage figures have been converted from UK Sterling to Euro by means of Purchasing Power Parity (PPP) as per OPW guidance.

Capping values for both residential and commercial properties were determined using the residential property price register, commercial leases register and the property website daft.ie. Following OPW guidance the commercial capping values were calculated as ten times the current rateable value of the property.

18.2.9 Damage Analysis Results

The total damage frequency graph is presented in Figure 56. The results for the baseline damages scenario (4% discount rate) is presented in Table 22. It can be seen that the total benefit (damage avoided) for the scheme is €185.5M.

Figure 56: Total Damage-Frequency Graph for the Lower Lee

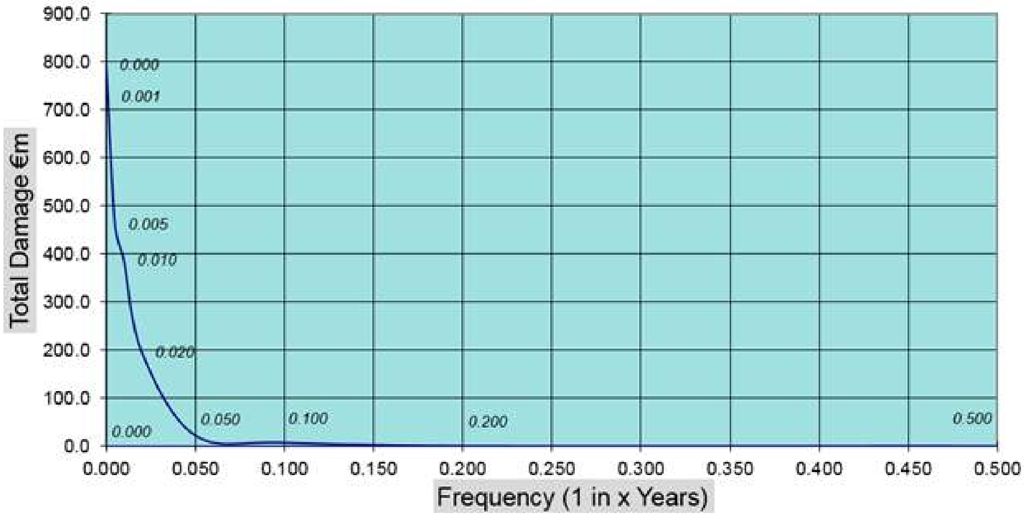


Table 22: Damages Assessment for the Lower Lee (4% discount rate)

Category	**Source**	**TDD 1% AEP Event (€M)**	**TDD 0.5% AEP Event (€M)**	**AAD (Fluvial & Tidal) (€M)**	**PV Damage Uncapped (€M)**	**Benefit / Damage avoided (€M)**
Direct Residential	Fluvial	32.97	35.52	1.31	29.38	**19.21**
	Tidal	2.73	5.40			
Direct Commercial	Fluvial	172.99	197.25	6.65	148.79	**87.12**
	Tidal	24.2	40.9			
Intangible Residential	Fluvial	32.97	35.52	1.31	29.38	**19.21**
	Tidal	2.73	5.40			
Intangible Commercial	Fluvial	34.41	39.02	1.33	29.81	**18.68**
	Tidal	6.18	10.16			
Traffic @ 5% of PDD	Fluvial & Tidal	11.64	13.95	0.39	8.9	**6.23**
Emergency Services @ 8.1% of PDD	Fluvial & Tidal	18.86	22.6	0.64	14.43	**10.09**

Category	Source	TDD 1% AEP Event (€M)	TDD 0.5% AEP Event (€M)	AAD (Fluvial & Tidal) (€M)	PV Damage Uncapped (€M)	Benefit / Damage avoided (€M)
Utilities @ 20% of PDD	Fluvial & Tidal	46.58	55.82	1.59	35.63	**24.94**
				TOTAL	**296.4**	**185.5**

18.3 Damages/Benefit Ignored from the Analysis

We have conservatively ignored the damages/benefit arising from a number of sources in our analysis in order to adopt a conservative approach. These are:

- The likely underestimation of tidal water levels in the hydraulic model that was used to generate the tidal water levels for the damages analysis.
- The operation of the dams under design conditions which will provide benefit above the 1% AEP fluvial event.
- Damages arising from disruption of business.

Each of these three items are considered in our sensitivity analysis below.

18.3.1 Underestimation of Tidal Water Levels

The hydraulic model was calibrated against the tidal flood event of February 2014 which approximated to a 1 in 25 year tidal event. The model under predicted the flood extent in a number of areas such as Patrick Street due to the absence of drains, gullies and small gaps from the hydraulic model which limited the volume of water exiting the channel and entering the floodplain.

The model's under prediction of the 2014 event was investigated by undertaking a sensitivity analysis on the design runs. It was found that by raising the tidal water levels by 100mm the model reproduced the recorded flood extent and depth across the city.

We have therefore undertaken a sensitivity analysis on the damages assessment by considering a 100mm increase in the tidal water levels across the city for each of the return period events. We have not considered the greater number of properties that would be flooded for each event with a 100mm increase, we have just added the increase to each of the properties already flooded for each event, (this is therefore conservative).

The results of the sensitivity analysis are presented in the following table. It can be seen that the total benefit is increased by circa €26M from €185.5M (baseline damages) to €212.2M.

Table 23: Damages Assessment – Sensitivity on the Tidal Damages Scenario 1 (4% Discount Rate)

	Benefit (€M) - Baseline scenario	**Benefit (€M) - Sensitivity Analysis 1. Tidal levels increased by 100mm for all return period events**
Direct Residential	19.21	20.8
Direct Commercial	87.12	101.4
Intangible Residential	19.21	20.8
Intangible Commercial	16.68	22.1
Traffic	6.23	7.1
Emergency Services	10.09	11.5
Utilities	24.94	28.5
TOTALS	185.5	212.2

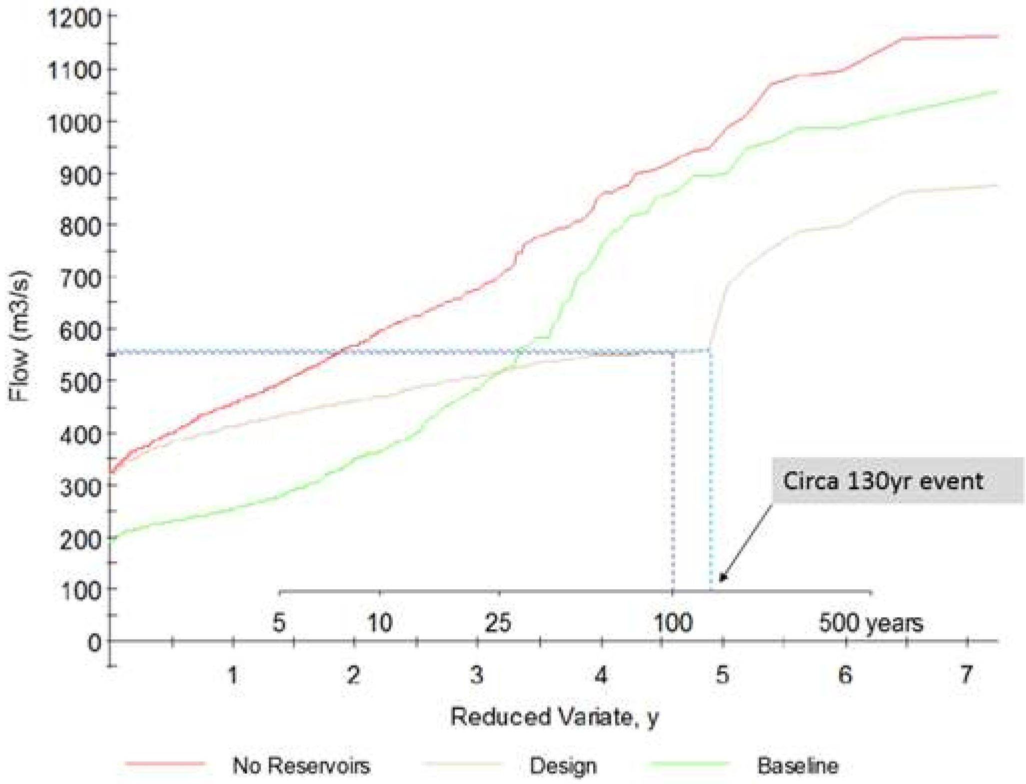
18.3.2 Operation of the Dams

No benefit has been taken for events above either the 1% AEP fluvial event or 0.5% AEP tidal event in our baseline scenario. While this approach is in line with all OPW schemes, it is a particularly conservative approach for the Lower Lee scheme as the Flood Forecasting System and revised dam operation will reduce the flood frequency curve above the 1% AEP and hence increase the benefit of the scheme.

Figure 8-4 from the Lower Lee FRS Hydrology report is reproduced in Figure 57 of this report. The figure presents the flood frequency curves at the Waterworks weir for three separate scenario events: No reservoirs, design and baseline.

The dashed purple line has been superimposed on the graph to highlight that the 100 year design flow at the Waterworks Weir is circa 555m^3/s. It can be seen using the dashed blue line superimposed on the graph that a flow rate of circa 555m^3/s is maintained up to approximately the 130 design return period event owing to the attenuation and operation of the dams during design conditions.

Figure 57: Figure 8-4 from the Hydrology Report



We have undertaken a sensitivity analysis on the baseline damages to consider the benefit from a 130 year fluvial/200 year tidal standard of protection of the scheme.

The sensitivity indicates that the total benefit of the scheme is increased by circa **€8.5M** from **€185.5M** to **€194.2M** when the higher standard is adopted.

The operation of the dams will also provide benefit above the 130 year fluvial/200 year tidal standard. It can be seen from Figure 48 that the design flow is considerably less than the baseline flow scenario above the 130 year event. For the 500 year event the design flow is circa 830m^3/s while the baseline flow is circa 1000m^3/s. This implies that the operation of the dam as part of the scheme will further attenuate the 500 year return period event by circa 170m^3/s which will provide additional benefit to the study area above the design standard of the scheme which has not been considered as part of our analysis.

18.3.3 Loss of Business Costs

MCM 2014 notes that most commercial properties are likely to incur indirect losses during flood events.

These include the cost of additional work, overtime working and efforts to minimise or avoid disruption. The MCM notes that these indirect losses can be accounted for by an allowance of 3% of the PDD.

We have undertaken a sensitivity analysis of the baseline damages by considering a 3% uplift associated with losses due to businesses.

The sensitivity indicates that the total benefit of the scheme is increased by circa €2.5M from €185.5M to €188.0M when the higher standard of the scheme is adopted.

18.4 Cost Benefit Analysis of the Scheme

18.4.1 Costs

18.4.1.1 Present Value Costs

The Present Value Costs provide an indication of the cost today of the works over their lifetime.

18.4.1.2 Capital Works Costs

The present value of costs is based on a 50-year design life for each option or scheme that is capable of protecting against a 1 in 100 year flood event.

The scheme will be constructed over an eight year period in a number of distinct phases. In estimating the benefit cost ratio however we have not undertaken any discounting of the costs and have assumed that the total cost of the scheme will be expended in the first year (2017). This is adopting a conservative approach and allows a direct comparison with our estimated damages which have all been discounted to 2017.

The capital costs of the scheme have been estimated as €109M.

18.4.1.3 Maintenance Costs

The maintenance costs of the scheme discounted to year 0 (2017) are estimated at €19.44M.

18.4.2 Economic Comparison

OPW has advised that the appropriate discount rate to be applied should be 4%.

18.4.3 Benefit Cost Analysis Summary

Figure 12 presents the Benefit Cost Analysis based on Discount Rate of 4%. IT can be seen that the BCR is calculated as 1.44.

Table 24: Cost Benefit Analysis Summary for Baseline Damages and Preferred Option

	Preferred Option - 4% DR (€M)
Present Value Costs (PVc)	128.45

	Preferred Option - 4% DR (€M)
Residual damages (100yr fluvial & 200yr tidal scheme) (PVd)	88.19
Present Value Benefit (PVb)	185.45
Net Present Value (NPV)	57.01
Benefit Cost Ratio (BCR)	1.44

18.4.4 Sensitivity Analysis

A sensitivity assessment has also been carried undertaken which considers a 5% reduction in benefits as well as 3% and 5% discount rate. The results of the sensitivity are presented in Table 23. It can be seen the BCR for the most conservative assumption (5% DR) is calculated as 1.21.

Table 25: Cost Benefit Analysis Sensitivity Analysis

	3% DR (€M)	5% DR (€M)	5% reduction in benefit
Present Value Costs (PVc)	128.45	128.45	128.45
Residual damages (100yr fluvial & 200yr tidal scheme) (PVd)	104.61	75.66	88.19
Present Value Benefit (PVb)	224.20	155.90	176.18
Net Present Value (NPV)	95.75	27.45	47.73
Benefit Cost Ratio (BCR)	1.74	1.21	1.37

18.4.5 Conclusion of Benefit Cost Analysis

Benefits and costs for the preferred option were compared with those of the Do Minimum case to provide a convenient common baseline against which the proposed scheme can be assessed.

The Cost Benefit Analysis was tested for sensitivity versus discount rates of 3% and 5% and a 5% reduction in benefit.

The Cost benefit analysis shows that the proposed scheme is cost-beneficial for both the recommended discount rate of 4% (BCR = 1.44) and the more conservative discount rate of 5% (BCR = 1.21).

In order to adopt a conservative approach our analysis has ignored the damages from a number of sources:

- The likely underestimation of tidal water levels in the hydraulic model that was used to generate the tidal water levels for the damages analysis.
- The operation of the dams under design conditions which will provide benefit above the 1% AEP fluvial event.
- Damages arising from disruption of business.

Should these have been included as part of baseline damages assessment the benefit of the scheme would have been higher than our baseline figure of €185.5M. The Benefit Cost ratio would therefore also be higher.

19 Phasing of the Proposed Scheme

The phasing of the proposed scheme is outlined in detail in the Assessment of Phasing Options Report, March 2017. It was developed based on the following key criteria:

- Phase works in a way that maximises interim benefit in terms of incrementally reducing flood risk.
- Typical annual spend profile and individual contract values of approximately €15 Million.
- Avoidance of any increase in flood risk associated with the interim condition in comparison to the baseline condition.
- Practical consideration and potential combining of other projects.
- Ensuring contract phasing and timescales reasonably minimises disruption to businesses and landowners including Traffic considerations.

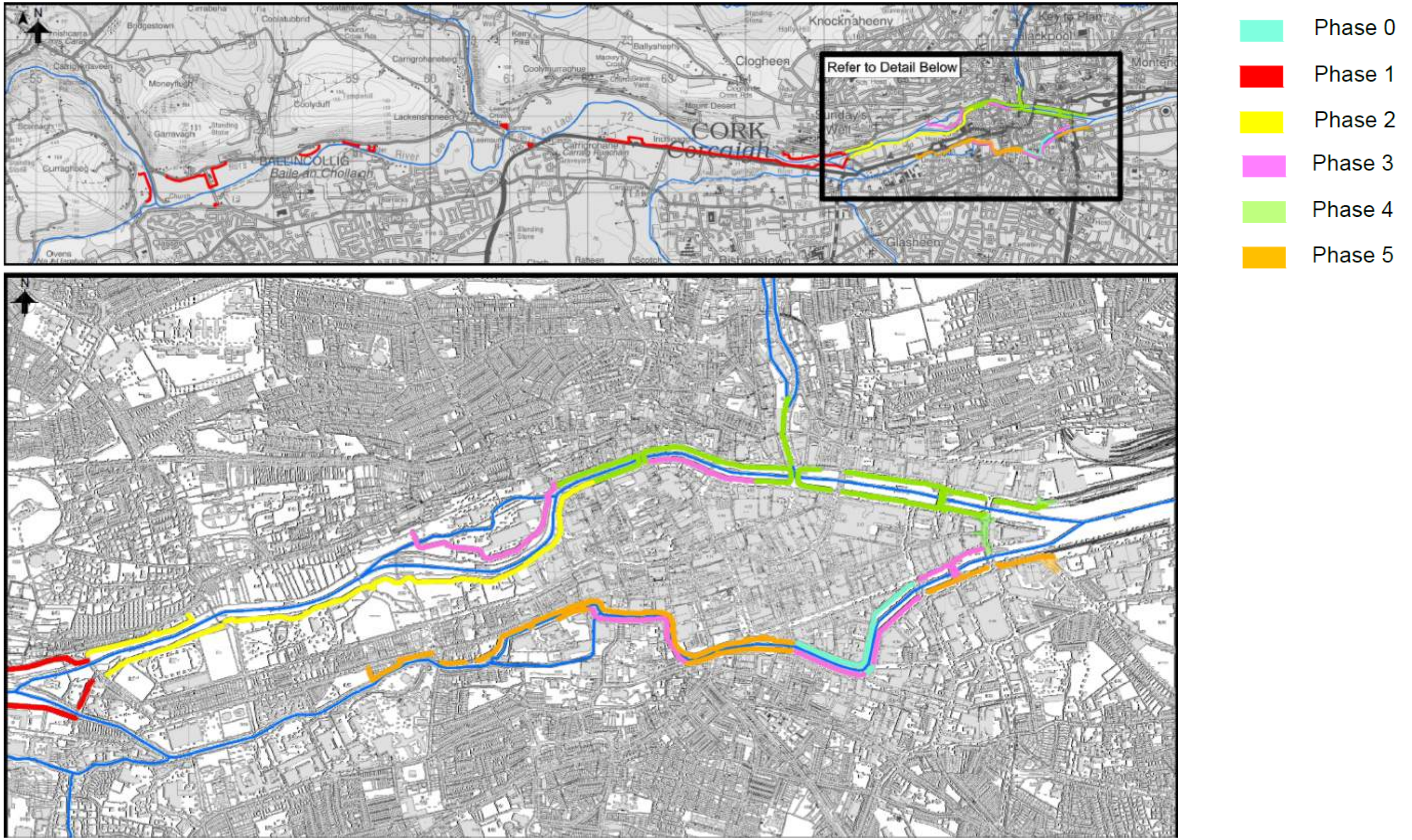
The costs and timescales for delivery of the proposed phases is set out in Table 26 below.

Table 26: Summary Detail - Proposed Phasing

Phase	Planning Route	Cost Estimate	Start	Finish
Morrison's Island	Part 8	€5.1m	Dec 2017	Dec 2018
Phase 1	ADA	€23.5m	Mar 2018	Sept 2019
Phase 2	ADA	€18.6m	Mar 2019	Sept 2020
Phase 3	ADA	€11.1m	Sept 2020	Mar 2022
Phase 4	ADA	€14.7m	Mar 2022	Sept 2023
Phase 5	ADA	€16.8m	Sept 2023	Sept 2024
Total		€89.8m		

The phasing of the proposed works is set out in Figure 58 below.

Figure 58: Location Plan of Proposed Phasing of Work



20 Conclusions

The extent and severity of the flood risk in the study area was established and defined through a detailed hydrology study, hydraulic modelling, flood mapping etc.

The design standard of protection (SOP) for the Scheme is the 1% AEP Fluvial/0.5% AEP Tidal.

The benefits of defending to the design standard of 1% AEP Fluvial/0.5% AEP tidal was established to inform a detailed cost benefit analysis.

From our initial hydrological and hydraulic assessment, it quickly became apparent that the existing case 1% AEP flow of circa 860m3/s could not be safely conveyed through Cork City without the need for unacceptably high defences which would destroy the character of the city and the relationship of the city with the river.

Therefore, a pre-requisite to developing a direct defence scheme through Cork was to reduce the peak flow for the design 1% AEP event through the use of revised dam operation procedures in conjunction with a flood forecasting system based on predicted rainfall at long lead times. This element has the beneficial effect of reducing the peak design flow reaching the city to 555m3/s.

As part of the revised dam operation procedures, greater advance discharges will be facilitated to create greater attenuation in the reservoirs ahead of major events. This will result in early/artificial flooding of floodplain areas upstream of Cork. These areas are known as 'Washlands' and are designated as part of the proposed scheme.

Once the revised design flow was established, it was then necessary to establish the extent and nature of defences required downstream of Inniscarra dam through to Custom House.

Following initial review, it was concluded that whilst there were some areas at risk of tidal flooding in the north and south docklands areas, there wasn't a cost beneficial scheme in these areas and flood risk in these reaches would be addressed through planning control as the expected redevelopment of these areas occur over the coming years.

Upstream of Inniscarra, direct defences are requires in discrete areas at Inniscarra bridge, Balincollig, Inchaggagin and Carrigrohane.

Consideration of potential alternative options was limited to the city reach from Inchaggagin to Custom House. Alternatives in this reach focussed on the split of flow between the north and south channel, the impact of the Curragheen flows on levels in the south channel and the potential to minimise defences on the south channel and Curragheen by limiting inflows into the south channel, from river flow and/or from the tide.

Following a review of the potential viable measures, 3 potentially viable options were developed to outline design level and can be summarised as follows:

- Option 1 – Direct Defences with Flow Reduction on South Channel (only tidal defences on South Channel)
- Option 2 - Direct Defences on North Channel only (with temporary isolation of South Channel in tidal event)
- Option 3 - Direct Defences throughout (no alteration to flow split between north and south channels)

All three options were then developed to outline design level including hydraulic modelling, outline design and costings.

A final decision on the preferred option was made based on a holistic evaluation of the following key aspects:

- Relative Cost of each Option.
- Findings of Multi-Criteria Analysis.
- Consideration of the key core messages which arose during the stakeholder consultation process.
- Consideration of Key Risks.
- Consideration of Climate Change Adaptability.
- Combined professional judgement of the steering group members.

Following this evaluation, Option 1 was selected as the preferred option for the following reason:

- It had the best scores in terms of all three of; MCA score, options selection score and MCA Benefit/Cost Ratio.
- Less expensive than the option of direct defences throughout (which otherwise would be next most preferable option).
- It requires work on the shortest length of channel (and therefore least disruption and environmental impact).
- No defences required on the Curragheen or fluvially dominated reach of south channel.
- Least intrusive scheme from a visual perspective and effects least amount of channel.
- Relatively straightforward automated operation of a single flow regulation structure.
- Most adaptable scheme from a climate change perspective.
- Offers greater flexibility in terms of managing different events than the direct defence only option where flow split at Salmon weir cannot be altered.

- The additional 400m in height of defences required on the fluvially dominated reach of the North Channel does not materially alter the nature or impact of the scheme defences in this reach.
- This option was presented to the public as the emerging preferred option and was generally met with a positive response.

Option 1 was then subjected to a detailed cost benefit analysis, including sensitivity test, which illustrated that this option had a strong cost benefit ratio of 1.44.

In terms of climate change adaptability of the direct defence elements to be constructed as part of the proposed scheme, the following is proposed:

- Direct defences between Inniscarra Dam and St.Vincent's Bridge to be designed to be adaptable for a future 1m increase in levels.
- Direct Defences in the tidally dominated city centre areas to be adaptable to be raised to a permanent defence height of 1.2mOD above dry side ground level or 4mOD.

Appendix A

Consideration of Potential Solutions Proposed by Members of the Public

A1 Consideration of Potential Solutions Proposed by Members of the Public

Proposal Title	General Description of proposal	Conclusion of Review
Proposed Pumped Bypass Culvert in North Channel	The concept of this proposal was to increase the hydraulic capacity of the limiting reaches by providing additional channelling. In this proposal, the limiting reaches were considered to be in the North Channel, from Sunday's Well Bridge to St.Vincent's Bridge. This was to be done by constructing an in-bed bypass culvert in the North Channel and by increasing the natural flow in the bypass by pumping. The pumping station was proposed to be located circa Sunday's Well Bridge, and the in-bed bypass channel would extend from there to St.Vincent's Bridge. As per the proposal, the overall pumping power required would be the order of 20,000kW and the maximum capacity would be the order of 190m/s.	This proposal does not consider flooding in the South Channel or tidal flooding, and therefore would not provide the standard of protection required by OPW for the whole scheme. Furthermore, the cost of the proposal would be prohibitive, the environmental impacts significantly negative. Technically, the required pump capacity is impractically large. Hence it was not considered further in the scheme design.
Filling in and Culverting of South Channel	A submission included a proposal which involves the filling in and/or culverting of the South Channel, providing land for civic use and avoiding requirement for flood defence walls.	This proposal does not consider the Curragheen and Glasheen rivers which discharge into the South Channel. These rivers would have to be permanently diverted which would result in significant defence requirements upstream on these rivers.

Proposal Title	General Description of proposal	Conclusion of Review
		This proposal would also fundamentally change the character of the river side city, would have significant environmental impacts and would have a significant construction cost. Hence it was not considered further in the scheme design.
Custom House Quay Defences	At the second PID (29 July 2014), where the emerging preferred option was presented, the scheme included defending Custom House Quay and Anderson Quay East. There was a submission suggesting that the proposed defence would render this quay unusable. It was highlighted that this quay is currently the only secure quay in the upper harbour and it is often used for ships which require security or exclusion zones. Furthermore the defences would require relocation of the mooring bollards which would require significant works to the quay foundations.	Following consideration of this issue, the defence concept has been revised to raising/re-grading of Custom House Street to provide the flood defence. The Custom House and warehouses would be left undefended, however the ground floor of Custom House is understood to be well elevated compared to the road level and would not flood during the design event. The revised solution was also discussed with Port of Cork Company, current owners of the site.
Pumped Storage at Macroom	The concept of this proposal is to pump the potential flood waters from Carrigadrohid Reservoir to a storage area in the hills between Macroom and Kilgarvan during a flood event.	This proposal has significant technical and environmental constraints due to the location, scale and distances involved in the proposed scheme, which would result in unfeasible construction and operation costs.

Proposal Title	General Description of proposal	Conclusion of Review
	The storage area would have a turbine and the water would be released periodically into the River Roughty at Kilgarvan and from there would flow into Kenmare bay. With the turbine it could generate its own electricity to power itself.	Hence it is not considered further in the scheme design.

Appendix B

Economic Assessment of Options

B1 Cost Estimates

B1.1 Option 1 – Flow Reduction In South Channel and Direct Defences

Project Title: Lower Lee Flood Relief Scheme		Job No:	230436-00
		Date:	December 2016
Area	**Area No**	**Element Name**	**Option 1** **Flow Reduction in South Channel**
Area 1			
West of Waterworks Weir	1A	Inniscarra	1,765,302
	1B	Ballincollig / Leemount	3,140,090
	1C	Inchigaggin/Carrigrohane Rd	3,310,483
	1D	Kingsley	2,799,201
	1E	Lee Road	637,000
		Sub-Total	**11,652,076**
Area 2: North Channel West			
North of North Channel West	2A	Lee Road	980,197
		Sunday's Well	1,954,190
		Distillery Fields	489,526
		Wise's Quay	461,543
South of North Channel West	2B	Salmon Weir	317,207
		Mardyke	1,312,362
		Fitzgerald's Park	2,563,911
		Dyke Parade	442,475
		Presentation School & Tyndall Institute	1,785,268
		Sub-Total	**10,306,679**
Area 3			
River Kiln	3	North City Link Rd	177,279
		Sub-Total	**177,279**
Area 4: North Channel East			
North of North Channel East	4A	North Mall	1,230,912
		Pope's Quay	1,365,261
		Camden Place	215,344
		St Patrick's Quay	1,602,856
		Penrose Quay	383,462
South of North Channel East	4B	Grenville Place	642,248
		Bachelor's Quay	1,250,099
		Griffith Bridge	95,000
		Kyrl's Quay	779,043
		Coal Quay	426,797
		Lavitt's Quay	356,319
		Christy Ring Bridge	147,000
		Merchant's Quay	683,856
		Anderson's Quay	585,808
		Brian Boru Bridge	159,800
		Custom House Street	429,670
		Sub-Total	**10,353,475**

Project Title: **Lower Lee Flood Relief Scheme**		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 1** **Flow Reduction in South Channel**
Area 5: South Channel East			
North of South Channel East	5A	Lapp's Quay East	311,100
		Clontarf Bridge	192,972
		Lapp's Quay West	681,723
		Morrison's Quay	1,781,447
		Father Mathew's Quay	1,046,773
		South Mall Properties	419,359
		Grand Parade Quay	497,877
		Dun Mhuire	114,203
		City Car Park	208,087
		Beamish and Crawford Yard	790,238
		Beamish and Crawford Yard	406,900
		Beamish and Crawford Yard	205,462
		Wandesford-Hanover St Properties	190,902
		Labour Exchange	334,592
		Waterside Quay	291,524
		Fisherman's Wharf	470,311
South of South Channel East	5B	Victoria Road	214,650
		Albert Quay East	386,238
		Albert Quay	791,479
		Terence MacSweeny Quay	272,252
		Union Quay	1,583,903
		George's Quay	441,564
		Sullivan's Quay	1,269,601
		French's Quay	375,194
		Crosse's Green Quay	880,335
		Wandesford Quay	632,805
		Crawford Hall	169,386
		Sub-Total	**14,960,875**
Area 6: South Channel West			
North of South Channel West	6A	St Finbarres Bridge	69,518
		Lancaster Quay	969,020
		Lancaster Lodge Bridge	19,697
		Hotel Bridge	19,697
		Inniscarrig Terrace	219,061
		Western Road	566,327
		Western Extent	0
South of South Channel West	6B	Mill Race Culvert	112,000
		Lancaster Lodge Quay	25,405
		Gill Abbey Branch and Glucksman	0
		Western Extent	0
		Sub-Total	**2,000,724**

Project Title: Lower Lee Flood Relief Scheme		Job No:	230436-00
		Date:	December 2016
Area	Area No	Element Name	Option 1
			Flow Reduction in South Channel
Area 7: Curragheen/Glasheen			
	7	Curragheen	0
		Glasheen	0
		Sub-Total	0
		Grand Total	49,451,108

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1A - Inniscarra**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	1531	828.50	1,268,439.62
1.2	**New Embankment - 18m wide @ 1:3 gradient, 2.55m high & 4m crown**	m	115	969.15	111,452.25
1.3	**New Embankment - 20m wide @ 1:3 gradient, 2.63m high & 4m crown**	m	78	1,005.21	78,406.69
1.4	**New Embankment - 10m wide @ 1:3 gradient, 1m high & 2m crown**	m	67	336.00	22,512.00
1.5	**Pumping station**	LS	3	75,000.00	225,000.00
1.6	**Vehicle access ramp**	No.	4	2,000.00	8,000.00
1.7	**Regrading of existing road**	m2	325	96.50	31,381.80
1.8	**Non-return valves (embankment)**	PS	1	20,110.00	20,110.00
	Total				**1,765,302.37**

	Cost Estimate			Job No:	230436-00
				Sheet No:	**2**
Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1B - Ballincollig/Leemount**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	362	828.50	299,918.45
1.2	**New Embankment - 10m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	19	828.50	15,741.58
1.3	**New Embankment - 10m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	146	590.82	86,259.72
1.4	**1m high Retaining Wall**	m	41	845.05	34,647.05
1.5	**1.5m high Retaining Wall**	m	44	1,269.59	55,861.85
1.6	**0.6m high Retaining Wall**	m	71	690.54	49,028.16
1.7	**Sheet pile flood defence wall (incl cladding on dry side)**	m	358	4,768.25	1,707,033.50
1.8	**New concrete pipe culvert**	m	45	750.00	33,750.00
1.9	**Pumping station**	LS	4	75,000.00	300,000.00
1.10	**Land to be reclaimed**	m2	497	100.06	49,719.99
1.11	**Non-return valves (embankment)**	PS	1	2,500.00	2,500.00
1.12	**Regrading of existing road**	m2	374	96.50	36,129.60
1.13	**Cut off to Embankment**	m	313	1,500.00	469,500.00
	Total				**3,140,089.90**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1C - Carrigrohane Rd**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 18m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	2020	828.50	1,673,578.08
1.2	**New Embankment - 12.5m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	618	590.82	365,126.76
1.3	**1.0m high Retaining Wall**	m	315	845.05	266,190.75
1.4	**Pumping station**	LS	4	75,000.00	300,000.00
1.5	**Vehicle access ramp**	item	11	2,000.00	22,000.00
1.6	**Connection of vehicle access ramp to existing footpath**	m2	583	50.00	29,130.00
1.7	**Road and turning area on top of embankment**	m2	779	50.00	38,970.00
1.8	**New carpark**	m2	2,524	125.00	315,487.50
1.9	**Cut off to embankment**	m	200	1,500.00	300,000.00
	Total				**3,310,483.09**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1D - Kingsley Area**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**1.6m high Retaining Wall**	m	248	1,269.59	314,857.70
	Capping beam + Cladding	m	248	200.00	49,600.00
1.2	**0.6m high Retaining Wall**	m	102	690.54	70,434.83
	1.2m high glass wall	m	102	2,000.00	204,000.00
1.3	**Removal and reinstatement of existing river wall and safety railing**	m	350	50.00	17,500.00
1.4	**Cut off to wall**	m	200	1,500.00	300,000.00
1.5	**Steps to maintain access**	no	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	233	96.50	22,465.20
1.7	**Regrading of existing footpath**	m2	1,250	41.09	51,365.56
1.8	**1.2m high Retaining Wall**	m	94	950.61	88,977.33
1.9	**Pumping station**	item	1	75,000.00	75,000.00
1.10	**Flow regulation structure - existing footbridge to be removed and footbridge**	LS	1	1,600,000.00	1,600,000.00
	Total				**2,799,200.61**

Cost Estimate			Job No:		230436-00
			Sheet No:		**5**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1E - Lee Road**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Refurbishment/raising of existing embankment - 1:3 gradient side slopes &**	m	363	336.00	121,968.00
1.2	**Refurbishment/raising of existing embankment - 1:2 gradient side slopes &**	m	33	500.00	16,500.00
1.3	**Refurbishment/raising of existing embankment - 1:1 engineered side**	m	87	1,000.00	87,000.00
1.4	**1.0m high Retaining Wall**	m	40	845.05	33,802.00
1.5	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	690	96.50	66,594.65
1.7	**Regrading of existing footpath**	m2	153	41.09	6,299.47
1.8	**Refurbish of existing masonry wall**	m	80	400.00	32,000.00
1.9	**1.0m high Retaining Wall**	m	82	845.05	69,294.10
1.10	**Vehicle access ramp**	item	1	2,000.00	2,000.00
1.11	**Pumping station**	item	2	75,000.00	150,000.00
1.12	**New culvert (2.0m wide by 1.2m high)**	m	20	1,927.07	38,541.37
1.13	**Replacement of Existing Sluice Valve**	item	1	8,000.00	8,000.00
	Total				**636,999.59**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West**				
	Lee Road				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**1.2m high Retaining Wall**	m	216	950.61	205,332.30
	Coping + Cladding	m	648	100.00	64,800.00
	Reinstate existing roadway	m2	800	96.50	77,200.00
1.2	**1.5m high Retaining Wall (including cladding)**	m	82	1,369.59	112,306.18
	Footpath	m2	147.6	41.09	6,065.24
1.3	**Steel Flood Defence wall**	m	8	2,500.00	20,000.00
1.4	**Quay Wall Type 5: Sheet pile flood defence wall (incl cladding on dry side)**	m	72	4,718.25	339,714.00
1.5	**Non-return valves**	PS	1	30,500.00	30,500.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
1.7	**Vehicle access ramp**	m2	150	100.00	15,000.00
	Reinforced concrete wall to support ramp -	m	27	1,269.59	34,278.86
	Total				**980,196.58**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Sundays Well**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall**	m	361	4,668.25	1,685,238.25
	Cladding	m	361	100.00	36,100.00
	Reinstatement of footpath	m2	722	41.09	29,666.98
1.2	**2.0m high Retaining Wall**	m	37	1,991.17	73,673.20
	Cladding (random rubble cladding)	m	37	100.00	3,700.00
1.3	**Parapet Wall Type 1**	m	23	300.50	6,911.50
1.4	**Demolition of existing parapet wall**	m	252	75.00	18,900.00
1.5	**Non-return valves (wall)**	PS	1	25,000.00	25,000.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,954,189.93**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Distillery Fields**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 8m wide @ 1:3 gradient, 1.0m high & 4m crown**	m	100	336.00	33,600.00
1.2	**New Embankment - 12.5m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	254	590.82	150,068.28
1.3	**0.7m high Retaining Wall (incl fencing)**	m	218	897.90	195,742.20
1.4	**New reinforced concrete footbridge**	LS	1	80,000.00	80,000.00
1.5	**Proposed headwall and penstock**	LS	1	20,000.00	20,000.00
1.6	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.7	**Regrading of existing footpath**	m2	125	41.09	5,116.01
	Total				**489,526.49**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Wises Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	74	1,398.19	103,465.88
1.2	**Railing**	m	17	500.00	8,500.00
1.3	**Quay Wall Type 1**	m	57	2,550.43	145,374.23
1.4	**Non-return valves (wall)**	PS	1	4,000.00	4,000.00
1.5	**Proposed penstock structure**	PS	1	30,000.00	30,000.00
1.6	**Remedial works to existing to ensure masonry arches can withstand uplift**	PS	1	31,000.00	31,000.00
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
1.8	**Regrading of existing road**	m2	170	96.50	16,405.00
1.9	**Regrading of existing footpath**	m2	25	41.09	1,027.31
1.10	**1.2m high Retaining Wall**	m	49	950.61	46,770.14
	Total				**461,542.55**

Cost Estimate			Job No:		230436-00
			Sheet No:		**5**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Salmon Weir Area**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 20m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	84	828.50	69,594.34
1.2	**Regrading of existing footpath**	m2	623	41.09	25,588.27
1.3	**Demolition of existing wall**	m	40	100.00	4,000.00
1.4	**1.2m high Retaining Wall**	m	40	950.61	38,024.50
1.5	**Embankment Cut off**	m	120	1,500.00	180,000.00
	Total				**317,207.10**

Cost Estimate			Job No:		230436-00
			Sheet No:		**6**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Mardyke**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**1.6m high Retaining Wall**	m	61	1,269.59	77,444.84
1.2	**2.3m high Retaining Wall**	m	486	1,991.17	967,707.41
1.3	**Non-return valves (wall)**	PS	1	26,000.00	26,000.00
1.4	**Regrading of existing footpath**	m2	720	100.00	71,960.00
1.5	**Railing**	m	179	500.00	89,250.00
1.6	**Access steps**	item	1	5,000.00	5,000.00
1.7	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,312,362.24**

Cost Estimate			Job No:		230436-00
			Sheet No:		**7**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Fitzgerald Park**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**1.2m high Retaining Wall**	m	259	950.61	246,208.64
1.2	**Glass flood defence wall, 1.2m high, to be constructed on top of retaining wall/sheet pile wall**	m	293	2,000.00	586,000.00
1.3	**1.2m high Retaining Wall**	m	116	950.61	110,271.05
1.4	**Quay Wall Type 5: Sheet pile wall**	m	250	4,668.25	1,167,062.50
	timber cladding on dry side	m	131	50.00	6,550.00
1.5	**Handrail - 1.2m high**	m	43	500.00	21,500.00
1.6	**Non-return valves (wall)**	PS	1	30,300.00	30,300.00
1.7	**Regrading of existing road**	m2	164	96.50	15,816.35
1.8	**Regrading of existing footpath**	m2	311	41.09	12,787.97
1.9	**Embankment/Infill @ 1:10 gradient**	m	23	150.00	3,465.00
1.10	**Embankment/Infill @ 1:7 gradient**	m	212	150.00	31,725.00
1.11	**Embankment/Infill @ 1:1 gradient**	m	83	150.00	12,375.00
1.12	**Vehicle access ramp**	item	8	2,000.00	16,000.00
1.13	**Access steps**	item	3	5,000.00	15,000.00
1.14	**New footpath**	m2	284	41.09	11,649.71
1.15	**Landing, approximately 2.1 to 2.4m**	m2	107	41.09	4,413.33
1.16	**Landing, approximately 1 to 1.3m above**	m2	314	41.09	12,886.59
1.17	**Backfill/land to be reclaimed**	m2	99	100.00	9,900.00
1.18	**Pumping station**	item	2	75,000.00	150,000.00
1.19	**Architectural Landscaping**	item	1	100,000.00	100,000.00
	Total				**2,563,911.13**

Cost Estimate			Job No:		230436-00
			Sheet No:		**8**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Dyke Parade**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	53	828.50	43,910.71
1.2	**New Embankment - 20m wide @ 1:3 gradient, 2.63m high & 4m crown**	m	219	1,005.21	220,141.87
1.3	**New Embankment - 10m wide @ 1:1 gradient, 2.5m high & 4m crown**	m	50	590.82	29,541.00
1.4	**New Embankment - 10m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	81	590.82	47,856.42
1.5	**Non-return valves (embankment)**	PS	1	4,000.00	4,000.00
1.6	**Relocation of existing fence to top of**	m	131	75.00	9,825.00
1.7	**Regrading of existing footpath**	m2	297	41.09	12,200.35
1.8	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**442,475.34**

Cost Estimate			Job No:		230436-00
			Sheet No:		**9**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Presentation School & Tyndall Institute**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall**	m	302	4,668.25	1,409,811.50
1.2	**Non-return valves (wall)**	PS	1	20,000.00	20,000.00
1.3	**Backfill/land to be reclaimed**	m3	3,322	30.00	99,645.00
1.4	**Footpath**	m2	1,062	41.09	43,640.18
1.5	**0.8m high Retaining Wall - Courtyard Area**	m	40	1,345.84	53,833.50
1.6	**0.6m high Retaining Wall - Non-Courtyard Area (incl Railing)**	m	70	1,190.54	83,337.63
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**1,785,267.80**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**3A - Kiln**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Steel plate attached to existing North City**	m	141	750.00	105,750.00
1.2	**New concrete kerb on existing concrete**	m	15	1,068.63	16,029.38
1.3	**Replacement of existing timber/steel**	item	4	7,500.00	30,000.00
1.4	**Local defences fitted externally to double**	m	6	750.00	4,500.00
1.5	**Sealing existing building services/utilities**	sum	1	10,000.00	10,000.00
1.7	**Resealing of existing bridge joints**	item	11	1,000.00	11,000.00
	Total				**177,279.38**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East** **North Mall**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 3**	m	267	1,068.63	285,322.88
1.2	**Quay Wall Type 1**	m	249	2,550.43	635,055.83
1.3	**Relocation of existing historical railing to run along the inside of the footpath**	m	249	75.00	18,675.00
1.4	**Non-return valves**	PS	1	18,500.00	18,500.00
1.5	**Pumping station**	Item	1	75,000.00	75,000.00
1.6	**Regrading of existing road**	m2	1,739	96.50	167,765.25
1.7	**Regrading of existing footpath**	m2	745	41.09	30,593.32
	Total				**1,230,912.27**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Pope's Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 1**	m	423	2,550.43	1,078,829.78
1.2	**Parapet Wall Type 1**	m	230	300.50	69,115.00
1.3	**Parapet Wall Type 2 - Infill of existing access to river access steps**	m	10	1,398.19	13,981.88
1.4	**Parapet Wall Type 5**	m	226	423.50	95,711.00
1.5	**Non Flood Defence Glass Wall**	m	15	500.00	7,500.00
1.6	**Non-return valves**	PS	1	16,000.00	16,000.00
1.7	**Pumping station**	item	1	75,000.00	75,000.00
1.8	**Access steps & gate**	item	2	3,000.00	6,000.00
1.9	**Regrading of existing footpath**	m2	76	41.09	3,123.03
	Total				**1,365,260.68**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Camden Place**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 1**	m	48	2,550.43	122,420.40
1.2	**Parapet Wall Type 1**	m	48	300.50	14,424.00
1.3	**Non-return valves**	PS	1	3,500.00	3,500.00
1.4	**Pumping Station**	m	1	75,000.00	75,000.00
	Total				**215,344.40**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**4A - North of North Channel East** **St Patricks Quay** **1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	404	1,493.43	603,343.70
1.2	**Parapet Wall Type 3**	m	26	1,068.63	27,784.25
1.3	**Quay Wall Type 1**	m	302	2,550.43	770,228.35
1.4	**Non-return valves**	PS	1	29,500.00	29,500.00
1.5	**Pumping Station**	item	2	75,000.00	150,000.00
1.6	**Demountable steel flood gate**	No	2	11,000.00	22,000.00
	Total				**1,602,856.30**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Penrose Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	169	1,493.43	252,388.83
1.2	**Non-return valves**	PS	1	12,000.00	12,000.00
1.3	**Access steps & gate**	m	2.4	2,500.00	6,500.00
1.4	**Regrading of existing road**	m^2	1,105	96.50	106,593.90
1.5	**Regrading of existing footpath**	m^2	146	41.09	5,978.95
	Total				**383,461.68**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Grenville Place**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	97	1,398.19	135,624.19
1.2	**Quay Wall Type 1**	m	97	2,550.43	247,391.23
1.3	**Non-return valves**	PS	1	7,000.00	7,000.00
1.4	**Demountable flood defence gate**	No.	2	11,000.00	22,000.00
1.5	**Regrading of existing road**	m2	2,107	96.50	203,354.45
1.6	**Regrading of existing footpath**	m2	654	41.09	26,878.57
	Total				**642,248.43**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Bachelors Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	241	1,398.19	336,963.19
1.2	**Quay Wall Type 3**	m	211	3,354.67	707,835.77
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Non-return valves**	PS	1	14,500.00	14,500.00
1.5	**Regrading of existing road**	m^2	1,200	96.50	115,800.00
	Total				**1,250,098.95**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Griffith Bridge**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New steel flood defence parapet**	m	95	1,000.00	95,000.00
	Total				**95,000.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Kryls Quay				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	213	1,398.19	297,813.94
1.2	**Quay Wall Type 1**	m	132	2,550.43	336,656.10
1.3	**Demountable steel flood gate**	No	1	11,000.00	11,000.00
1.4	**Non-return valves**	PS	1	11,500.00	11,500.00
1.5	**Regrading of existing road**	m2	2,971	41.09	122,073.32
	Total				**779,043.36**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Coal Quay				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 3**	m	155	1,068.63	165,636.88
1.2	**Quay Wall Type 1**	m	23	2,550.43	58,659.78
1.3	**Non-return valves**	PS	1	11,000.00	11,000.00
1.4	**Demountable steel flood gate**	No.	1	11,000.00	11,000.00
1.5	**Glass flood barrier**	m	14	2,000.00	28,000.00
1.6	**Pumping station**	item	1	150,000.00	150,000.00
1.7	**Access steps**	item	1	2,500.00	2,500.00
	Total				**426,796.65**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Lavitts Quay				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 5**	m	142	423.50	60,137.00
1.2	**Parapet Wall Type 1**	m	35	300.50	10,517.50
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Quay Wall Type 1**	m	42	2,550.43	107,117.85
1.5	**Quay Wall Type 2**	m	25	3,661.86	91,546.48
1.6	**Non-return valves**	PS	1	12,000.00	12,000.00
	Total				**356,318.83**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Christy Ring Bridge**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**New steel flood defence parapet**	m	147	1,000.00	147,000.00
	Total				**147,000.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Merchants Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	199	1,493.43	297,191.58
1.2	**Quay Wall Type 1**	m	33	2,550.43	84,164.03
1.3	**Non-return valves**	PS	1	2,500.00	2,500.00
1.4	**Pumping station**	item	2	150,000.00	300,000.00
	Total				**683,855.60**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Andersons Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	147	1,493.43	219,533.48
1.2	**Parapet Wall Type 5**	m	91	423.50	38,538.50
1.3	**Quay Wall Type 1**	m	84	2,550.43	214,235.70
1.4	**Non-return valves**	PS	1	16,500.00	16,500.00
1.5	**Pumping station**	item	1	75,000.00	75,000.00
1.6	**Demountable steel flood gate**	no.	2	11,000.00	22,000.00
	Total				**585,807.68**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East** **Brian Boru Bridge**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Road reconstruction**	m	120	300.00	36,000.00
1.2	**Steel flood defense parapet**	m	124	1,000.00	123,800.00
	Total				**159,800.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Custom House St**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Regrading of existing road**	m2	3,166	96.50	305,470.75
1.2	**Regrading of existing footpath**	m2	765	41.09	31,419.28
1.3	**Reinforced concrete retaining walls**	m	98	950.61	92,779.78
	Total				**429,669.81**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East**				
	Lapps Quay East				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Glass flood defence wall**	m	78	2,000.00	156,000.00
1.2	**Demountable steel access gate**	item	2	11,268.00	22,536.00
1.3	**Steel flip-up flood barrier**	item	3	44,188.00	132,564.00
	Total				**311,100.00**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Clontarf Bridge**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Road reconstruction**	m	123	300.00	36,900.00
1.2	**Steel flood defence upstand**	m	111	1,000.00	111,000.00
1.3	**Demountable steel flood gate**	no.	4	11,268.00	45,072.00
	Total				**192,972.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**5A - North of South Channel East** **Lapps Quay West** **1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	103	1,493.43	153,822.78
1.2	**Quay Wall Type 1**	m	103	2,550.43	262,693.78
1.3	**Non-return valves**	PS	1	7,500.00	7,500.00
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Regrading of existing road**	m2	1,555	96.50	150,009.25
1.6	**Public bike share docking station to be temporily removed and re-instated following raising of existing ground**	LS	1	20,000.00	20,000.00
1.7	**Footpath**	m2	309	41.09	12,697.57
	Total				**681,723.37**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Morrisons Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	321	1,493.43	479,389.43
1.2	**Quay Wall Type 1**	m	330	2,550.43	841,640.25
1.3	**Non-return valves**	PS	1	23,000.00	23,000.00
1.4	**Road regrading / resurfacing**	m2	2,564	96.50	247,426.00
1.5	**Pumping Station**	item	2	75,000.00	150,000.00
1.6	**Steel flip-up flood barrier**	item	1	39,991.00	39,991.00
	Total				**1,781,446.68**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East** **Fr Mathews Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	222	1,493.43	331,540.35
1.2	**Quay Wall Type 1**	m	222	2,550.43	566,194.35
1.3	**Non-return valves**	PS	1	15,000.00	15,000.00
1.4	**Road regrading / resurfacing**	m2	1,389	96.50	134,038.50
	Total				**1,046,773.20**

Cost Estimate			Job No:		230436-00
			Sheet No:		**6**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East**				
	South Mall Properties				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet pile wall**	m	58	4,668.25	270,758.50
1.2	**Removal of section of existing boardwalk**	m	6	500.00	3,000.00
1.3	**Pedestrian access ramp/boardwalk (incl retaining wall, privacy barrier and railing)**	item	1	145,600.00	145,600.00
	Total				**419,358.50**

Cost Estimate			Job No:		230436-00
			Sheet No:		**7**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Grand Parade Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Steel flip-up flood barrier**	PS	5	44,188.00	350,000.00
1.2	**Proposed reinforced concrete wall (incl wooden finish)**	m	72	945.05	68,043.60
1.3	**0.6m high reinforced concrete retaining wall**	m	7	690.54	4,833.76
1.4	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**497,877.36**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Dun Mhuire**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 1**	m	36	2,550.43	91,815.30
1.2	**Parapet Wall Type 5**	m	8	423.50	3,388.00
1.3	**Waterproofing Works to Building**	PS	1	19,000.00	19,000.00
	Total				**114,203.30**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East City Car Park**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 5 (incl railing)**	m	51	523.50	26,698.50
1.2	**Parapet Wall Type 1**	m	18	300.50	5,409.00
1.3	**Quay Wall Type 1**	m	69	2,550.43	175,979.33
	Total				**208,086.83**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford Yard**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	150	5,268.25	790,237.50
	Total				**790,237.50**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	63	5,268.25	331,899.75
1.2	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**406,899.75**

Cost Estimate			Job No:		230436-00
			Sheet No:		**12**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford Kegging**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	39	5,268.25	205,461.75
	Total				**205,461.75**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Wandesford-Hanover St Properties**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	18	1,493.43	26,881.65
1.2	**Raising of flood defence along balcony (steel plates)**	m	15	500.00	7,500.00
1.3	**Quay Wall Type 4**	m	41	3,817.56	156,520.06
	Total				**190,901.71**

Cost Estimate			Job No:		230436-00
			Sheet No:		**14**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Labour Exchange**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	63	1,493.43	94,085.78
1.2	**Quay Wall Type 4**	m	63	3,817.56	240,506.44
	Total				**334,592.21**

Cost Estimate			Job No:		230436-00
			Sheet No:		**15**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Waterside Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing and cladding)**	m	55	5,218.25	287,003.75
1.2	**Footpath**	m2	110	41.09	4,520.17
	Total				**291,523.92**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Fishermans Wharf**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	91	5,168.25	470,310.75
	Total				**470,310.75**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Victoria Rd**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Regrading of existing road**	m2	2,026	96.50	195,537.95
1.2	**Regrading of existing footpath**	m2	465	41.09	19,112.10
	Total				**214,650.05**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East**				
	Albert Quay East				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	175	1,493.43	261,349.38
1.2	**Footpath reinstatement**	m2	350	73.97	25,888.24
1.3	**Steel plate flood defence upstand**	m	11	1,000.00	11,000.00
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Non-return valves**	PS	1	13,000.00	13,000.00
	Total				**386,237.62**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East**				
	Albert Quay				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolition and disposal of existing**	PS	1	50,000.00	50,000.00
1.2	**Quay Wall Type 5: Sheet Pile Wall (incl railing & cladding)**	m	91	5,268.25	479,410.75
	Extra over for concrete infill	m3	2134	80.00	170,720.00
1.3	**Footpath**	m2	228	41.09	9,348.53
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**791,479.28**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Terence MacSweeny Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	93	1,493.43	138,888.53
1.2	**Regrading of existing road**	m	1,226	96.50	118,309.00
1.3	**Regrading of existing footpath**	m	196	41.09	8,054.12
1.4	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**272,251.64**

Cost Estimate			Job No:		230436-00
			Sheet No:		**5**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Union Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 3**	m	271	1,068.63	289,597.38
1.2	**Quay Wall Type 3**	m	303	3,354.67	1,016,465.58
1.3	**Glass flood defence wall**	m	30	2,000.00	60,000.00
1.4	**Steel flip up flood defence barrier**	item	1	39,991.00	39,991.00
1.5	**Non-return valves**	PS	1	26,000.00	26,000.00
1.6	**Pumping station**	item	1	150,000.00	150,000.00
1.7	**Regrading of existing footpath**	m2	45	41.09	1,849.16
	Total				**1,583,903.11**

Cost Estimate			Job No:		230436-00
			Sheet No:		**6**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Georges Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 3**	m	78	1,068.63	83,352.75
1.2	**Parapet Wall Type 4**	m	142	1,493.43	212,066.35
1.3	**Glass flood defence wall**	m	20	2,000.00	40,000.00
1.4	**Non-return valves**	PS	1	17,000.00	17,000.00
1.5	**Extension of access steps**	m	6	2,500.00	15,000.00
	0.8m high guard rail	m	15	500.00	7,250.00
	Access gate	item	1	300.00	300.00
1.6	**Existing footpath to be reinstated and extended**	m2	484	41.09	19,888.74
1.7	**Existing road to be reinstated**	m3	484	96.50	46,706.00
					0.00
	Total				**441,563.84**

Cost Estimate			Job No:		230436-00
			Sheet No:		**7**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Sullivans Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 4**	m	229	1,493.43	341,994.33
1.2	**Quay Wall Type 3**	m	233	3,354.67	781,638.55
1.3	**Non-return valves**	PS	1	16,000.00	16,000.00
1.4	**Demountable pedestrian access gate**	item	1	46,568.00	46,568.00
1.5	**Pumping station**	item	1	75,000.00	75,000.00
1.6	**Extension of access steps**	item	1	2,500.00	2,500.00
	Guard rail	m	11	500.00	5,400.00
	Access gate	item	1	500.00	500.00
	Total				**1,269,600.87**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Frenchs Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 1**	m	122	300.50	36,661.00
1.2	**Quay Wall Type 1**	m	92	2,550.43	234,639.10
1.3	**Quay Wall Type 4**	m	2	3,817.56	7,635.13
1.4	**Demountable pedestrian access gate**	item	1	12,759.00	12,759.00
1.5	**Culvert repair works**	PS	1	75,000.00	75,000.00
1.6	**Non-return valves**	PS	1	8,500.00	8,500.00
	Total				**375,194.23**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Crosses Green Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolition of existing concrete parapet**	m	145	75.00	10,875.00
1.2	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	145	5,168.25	749,396.25
1.3	**Cladding: 150mm random rubble limestone**	m2	79	100.00	7,900.00
1.4	**Existing footpath to be reinstated and extended**	m2	290	41.09	11,916.81
1.5	**Existing road to be reinstated**	m3	158	96.50	15,247.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
1.7	**Non-return valves**	PS	1	10,000.00	10,000.00
	Total				**880,335.06**

Cost Estimate			Job No:		230436-00
			Sheet No:		**10**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Wandesford Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	105	1,398.19	146,809.69
1.2	**Quay Wall Type 2**	m	105	3,661.86	384,495.23
1.3	**Non-return valves**	PS	1	6,500.00	6,500.00
1.4	**Temporary removal and reinstatement of bicycle scheme**	LS	1	20,000.00	20,000.00
1.5	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**632,804.92**

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			Sheet No:		**11**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Crawford Hall**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	63	1,398.19	88,085.81
1.2	**Glass flood defence wall**	m	37	2,000.00	74,000.00
1.3	**Demolition of existing railing**	m	20	40.00	800.00
1.4	**Non-return valves**	PS	1	6,500.00	6,500.00
	Total				**169,385.81**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West**				
	St Finbarres Bridge				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolish existing railing**	m	60	40.00	2,400.00
1.2	**Parapet Wall Type 3**	m	60	1,068.63	64,117.50
	Extra over for doweling into bridge deck	m	60	50.00	3,000.00
	Total				**69,517.50**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Lancaster Quay**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	12	1,398.19	16,778.25
1.2	**Parapet Wall Type 1**	m	240	300.50	72,120.00
1.3	**Quay Wall Type 3**	m	240	3,354.67	805,121.25
1.4	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**969,019.50**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Lancaster Lodge Brdge**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolish existing railing**	m	17	40.00	680.00
1.2	**Parapet Wall Type 3**	m	17	1,068.63	18,166.63
	Extra over for doweling into bridge deck	m	17	50.00	850.00
	Total				**19,696.63**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West**				
	Hotel Bridge				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolish existing railing**	m	17	40.00	680.00
1.2	**Parapet Wall Type 3**	m	17	1,068.63	18,166.63
	Extra over for doweling into bridge deck	m	17	50.00	850.00
	Total				**19,696.63**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Inniscarrig Terrace**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Parapet Wall Type 2**	m	8	1,398.19	11,185.50
1.2	**Parapet Wall Type 1**	m	29	300.50	8,714.50
1.3	**Quay Wall Type 5: Sheet Pile Wall**	m	17	4,668.25	79,360.25
1.4	**New Embankment, 2m wide crest**	m	141	261.00	36,801.00
1.5	**Non-return valves**	PS	1	8,000.00	8,000.00
1.6	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**219,061.25**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Western Road**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Demolition of existing steel fencing**	m	56	40.00	2,240.00
1.2	**Retaining Wall - 0.6m high**	m	106	400.00	42,400.00
1.3	**Railing**	m	97	100.00	9,700.00
1.4	**Parapet Wall Type 1**	m	49	300.50	14,724.50
1.5	**Quay Wall Type 5: Sheet Pile Wall**	m	107	4,668.25	499,502.75
	Total				**566,327.25**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West**				
	Mill Race Culvert				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**Culvert repair works (5m wide)**	m	105	1,000.00	105,000.00
1.2	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**112,000.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West Lancaster Lodge Qy**				
Option	**1 - Flow Reduction of South Channel and Direct Defences**				
1.1	**0.6m high Retaining Wall**	m	10	690.54	6,905.38
1.2	**0.2m Kerb**	m	70	50.00	3,500.00
1.3	**Railing**	m	10	500.00	5,000.00
1.4	**Non-return valves**	PS	1	5,000.00	5,000.00
1.5	**Existing structure to be sealed**	PS	1	5,000.00	5,000.00
	Total				**25,405.38**

B1.2 Option 2 – Isolation of South Channel and Direct Defences

Project Title: Lower Lee Flood Relief Scheme		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 2 Isolation of South Channel**
Area 1			
West of Waterworks Weir	1A	Inniscarra	1,765,302
	1B	Ballincollig / Leemount	3,140,090
	1C	Inchigaggin/Carrigrohane Rd	3,310,483
	1D	Kingsley	2,799,201
	1E	Lee Road	637,000
		Sub-Total	**11,652,076**
Area 2: North Channel West			
North of North Channel West	2A	Lee Road	980,197
		Sunday's Well	1,992,101
		Distillery Fields	554,733
		Wise's Quay	478,790
South of North Channel West	2B	Salmon Weir	332,051
		Mardyke	1,312,362
		Fitzgerald's Park	2,611,578
		Dyke Parade	469,103
		Presentation School & Tyndall Institute	1,845,668
		Sub-Total	**10,576,583**
Area 3			
River Kiln	3	North City Link Rd	177,279
		Sub-Total	**177,279**
Area 4: North Channel East			
North of North Channel East	4A	North Mall	1,278,476
		Pope's Quay	1,365,261
		Camden Place	215,344
		St Patrick's Quay	1,602,856
		Penrose Quay	383,462
South of North Channel East	4B	Grenville Place	664,857
		Bachelor's Quay	1,306,271
		Griffith Bridge	106,875
		Kyrl's Quay	779,043
		Coal Quay	426,797
		Lavitt's Quay	356,319
		Christy Ring Bridge	147,000
		Merchant's Quay	683,856
		Anderson's Quay	585,808
		Brian Boru Bridge	159,800
		Custom House Street	429,670
		Sub-Total	**10,491,693**

Project Title: **Lower Lee Flood Relief Scheme**		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 2 Isolation of South Channel**
Area 5: South Channel East			
North of South Channel East	5A	Lapp's Quay East	0
		Clontarf Bridge	0
		Lapp's Quay West	0
		Morrison's Quay	0
		Father Mathew's Quay	0
		South Mall Properties	0
		Grand Parade Quay	0
		Dun Mhuire	0
		City Car Park	0
		Beamish and Crawford Yard	0
		Beamish and Crawford Yard	0
		Beamish and Crawford Yard	0
		Wandesford-Hanover St Properties	0
		Labour Exchange	0
		Waterside Quay	0
		Fisherman's Wharf	0
South of South Channel East	5B	Victoria Road	214,650
		Albert Quay East	3,636,225
		Albert Quay	0
		Terence MacSweeny Quay	0
		Union Quay	0
		George's Quay	0
		Sullivan's Quay	0
		French's Quay	0
		Crosse's Green Quay	0
		Wandesford Quay	0
		Crawford Hall	0
		Sub-Total	**3,850,875**
Area 6: South Channel West			
North of South Channel West	6A	St Finbarres Bridge	0
		Lancaster Quay	0
		Lancaster Lodge Bridge	0
		Hotel Bridge	0
		Inniscarrig Terrace	0
		Western Road	0
		Western Extent	0
South of South Channel West	6B	Mill Race Culvert	0
		Lancaster Lodge Quay	0
		Gill Abbey Branch and Glucksman	0
		Western Extent	0
		Sub-Total	**0**

Project Title: Lower Lee Flood Relief Scheme		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 2 Isolation of South Channel**
Area 7: Curragheen/Glasheen	7	Curragheen	8,178,071
		Glasheen	1,376,918
		Sub-Total	**9,554,989**
		Grand Total	**46,303,494**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1A - Inniscarra**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	1531	828.50	1,268,439.62
1.2	**New Embankment - 18m wide @ 1:3 gradient, 2.55m high & 4m crown**	m	115	969.15	111,452.25
1.3	**New Embankment - 20m wide @ 1:3 gradient, 2.63m high & 4m crown**	m	78	1,005.21	78,406.69
1.4	**New Embankment - 10m wide @ 1:3 gradient, 1m high & 2m crown**	m	67	336.00	22,512.00
1.5	**Pumping station**	LS	3	75,000.00	225,000.00
1.6	**Vehicle access ramp**	No.	4	2,000.00	8,000.00
1.7	**Regrading of existing road**	m2	325	96.50	31,381.80
1.8	**Non-return valves (embankment)**	PS	1	20,110.00	20,110.00
	Total				**1,765,302.37**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1B - Ballincollig/Leemount**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	362	828.50	299,918.45
1.2	**New Embankment - 10m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	19	828.50	15,741.58
1.3	**New Embankment - 10m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	146	590.82	86,259.72
1.4	**1m high Retaining Wall**	m	41	845.05	34,647.05
1.5	**1.5m high Retaining Wall**	m	44	1,269.59	55,861.85
1.6	**0.6m high Retaining Wall**	m	71	690.54	49,028.16
1.7	**Sheet pile flood defence wall**	m	358	4,668.25	1,671,233.50
	Cladding to dry side (cladding to wet side incl. in sheet pile rate)	m2	358	100.00	35,800.00
1.8	**New 0.9m diameter concrete pipe culvert**	m	45	750.00	33,750.00
1.9	**Pumping station**	LS	4	75,000.00	300,000.00
1.10	**Land to be reclaimed**	m2	497	100.06	49,719.99
1.11	**Non-return valves (embankment)**	PS	1	2,500.00	2,500.00
1.12	**Regrading of existing road**	m2	374	96.50	36,129.60
1.13	**Cut off to Embankment**	m	313	1,500.00	469,500.00
	Total				**3,140,089.90**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1C - Carrigrohane Rd**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 18m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	2020	828.50	1,673,578.08
1.2	**New Embankment - 12.5m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	618	590.82	365,126.76
1.3	**1m high Retaining Wall**	m	315	845.05	266,190.75
1.4	**Pumping station**	LS	4	75,000.00	300,000.00
1.5	**Vehicle access ramp**	item	11	2,000.00	22,000.00
1.6	**Connection of vehicle access ramp to existing footpath**	m2	583	50.00	29,130.00
1.7	**Road and turning area on top of embankment**	m2	779	50.00	38,970.00
1.8	**New carpark**	m2	2,524	125.00	315,487.50
1.9	**Cut off to embankment**	m	200	1,500.00	300,000.00
	Total				**3,310,483.09**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1D - Kingsley Area**				
Option	**2 - Isolation of South Channel**				
1.1	**1.6m high Retaining Wall**	m	248	1,269.59	314,857.70
	Capping beam + Cladding	m	248	200.00	49,600.00
1.2	**0.6m high Retaining Wall**	m	102	690.54	70,434.83
	1.2m high glass wall	m	102	2,000.00	204,000.00
1.3	**Removal and reinstatement of existing river wall and safety railing**	m	350	50.00	17,500.00
1.4	**Cut off to wall**	m	200	1,500.00	300,000.00
1.5	**Steps to maintain access**	no	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	233	96.50	22,465.20
1.7	**Regrading of existing footpath**	m2	1,250	41.09	51,365.56
1.8	**1.2m high Retaining Wall**	m	94	950.61	88,977.33
1.9	**Pumping station**	item	1	75,000.00	75,000.00
1.10	**Flow regulation structure - existing footbridge to be removed and footbridge to be combined with flow control structure**	LS	1	1,600,000.00	1,600,000.00
	Total				**2,799,200.61**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1E - Lee Road**				
Option	**2 - Isolation of South Channel**				
1.1	**Refurbishment/raising of existing embankment - 1:3 gradient side slopes & 2m crown**	m	363	336.00	121,968.00
1.2	**Refurbishment/raising of existing embankment - 1:2 gradient side slopes & 2m crown**	m	33	500.00	16,500.00
1.3	**Refurbishment/raising of existing embankment - 1:1 engineered side slopes & 2m crown**	m	87	1,000.00	87,000.00
1.4	**1.0m high Retaining Wall**	m	40	845.05	33,802.00
1.5	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	690	96.50	66,594.65
1.7	**Regrading of existing footpath**	m2	153	41.09	6,299.47
1.8	**Refurbish of existing masonry wall**	m	80	400.00	32,000.00
1.9	**1.0m high Retaining Wall**	m	82	845.05	69,294.10
1.10	**Vehicle access ramp**	item	1	2,000.00	2,000.00
1.11	**Pumping station**	item	2	75,000.00	150,000.00
1.12	**New culvert (2.0m wide by 1.2m high)**	m	20	1,927.07	38,541.37
1.13	**Replacement of Existing Sluice Valve**	item	1	8,000.00	8,000.00
	Total				**636,999.59**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Lee Road**				
Option	**2 - Isolation of South Channel**				
1.1	**1.2m high Retaining Wall**	m	216	950.61	205,332.30
	Coping + Cladding	m	648	100.00	64,800.00
	Reinstate existing roadway	m2	800	96.50	77,200.00
1.2	**1.5m high Retaining Wall**	m	82	1,269.59	104,106.18
	Cladding (random rubble limestone cladding)	m	82	100.00	8,200.00
	Footpath	m2	147.6	41.09	6,065.24
1.3	**Steel Flood Defence wall**	m	8	2,500.00	20,000.00
1.4	**Quay Wall Type 5: Sheet pile flood defence wall**	m	72	4,668.25	336,114.00
	Timber cladding on dry side	m	72	50.00	3,600.00
1.5	**Non-return valves**	PS	1	30,500.00	30,500.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
1.7	**Vehicle access ramp**	m2	150	100.00	15,000.00
	Reinforced concrete wall to support ramp - 1.5m high	m	27	1,269.59	34,278.86
	Total				**980,196.58**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Sundays Well**				
Option	**2 - Isolation of South Channel**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall, 1.2m above E.G.L.**	m	252	4,668.25	1,176,399.00
	Cladding	m	252	100.00	25,200.00
	Reinstatement of footpath	m2	504	41.09	20,709.36
1.2	**Quay Wall Type 5: Sheet pile flood defence wall, 2.0m above E.G.L.**	m	109	4,718.25	514,289.25
	Cladding	m	109	100.00	10,900.00
	Reinstatement of footpath	m2	1008	41.09	41,418.72
1.3	**2.0m high Retaining Wall**	m	37	1,991.17	73,673.20
	Cladding (random rubble cladding)	m	37	100.00	3,700.00
1.4	**Parapet Wall Type 1**	m	23	300.50	6,911.50
1.5	**Demolition of existing parapet wall**	m	252	75.00	18,900.00
1.6	**Non-return valves (wall)**	PS	1	25,000.00	25,000.00
1.7	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,992,101.03**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Distillery Fields**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 6.5m wide @ 1:3 gradient, 0.85m high & 4m crown**	m	100	384.35	38,435.00
1.2	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	254	828.50	210,440.02
1.3	**0.85m high Retaining Wall (incl fencing)**	m	218	897.90	195,742.20
1.4	**New reinforced concrete footbridge**	LS	1	80,000.00	80,000.00
1.5	**Proposed headwall and penstock**	LS	1	20,000.00	20,000.00
1.6	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.7	**Regrading of existing footpath**	m2	125	41.09	5,116.01
	Total				**554,733.23**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Wises Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 2**	m	74	1,631.27	120,713.64
1.2	**Railing**	m	17	500.00	8,500.00
1.3	**Quay Wall Type 1**	m	57	2,550.43	145,374.23
1.4	**Non-return valves (wall)**	PS	1	4,000.00	4,000.00
1.5	**Proposed penstock structure**	PS	1	30,000.00	30,000.00
1.6	**Remedial works to existing to ensure masonry arches can withstand uplift forces**	PS	1	31,000.00	31,000.00
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
1.8	**Regrading of existing road**	m2	170	96.50	16,405.00
1.9	**Regrading of existing footpath**	m2	25	41.09	1,027.31
1.10	**1.2m high Retaining Wall**	m	49	950.61	46,770.14
	Total				**478,790.31**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Salmon Weir Area**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 20m wide @ 1:3 gradient, 2.63m high & 4m crown**	m	84	1,005.21	84,437.98
1.2	**Regrading of existing footpath**	m2	623	41.09	25,588.27
1.3	**Demolition of existing wall**	m	40	100.00	4,000.00
1.4	**1.2m high Retaining Wall**	m	40	950.61	38,024.50
1.5	**Embankment Cut off**	m	120	1,500.00	180,000.00
	Total				**332,050.74**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Mardyke**				
Option	**2 - Isolation of South Channel**				
1.1	**1.6m high Retaining Wall**	m	61	1,269.59	77,444.84
1.2	**2.3m high Retaining Wall**	m	486	1,991.17	967,707.41
1.4	**Non-return valves (wall)**	PS	1	26,000.00	26,000.00
1.5	**Regrading of existing footpath**	m2	720	100.00	71,960.00
1.6	**Railing**	m	179	500.00	89,250.00
1.7	**Access steps**	item	1	5,000.00	5,000.00
1.8	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,312,362.24**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Fitzgerald Park**				
Option	**2 - Isolation of South Channel**				
1.1	**1.2m high Retaining Wall**	m	259	950.61	246,208.64
1.2	**Glass flood defence wall**				
	1.2m high, to be constructed on top of retaining wall	m	259	2,000.00	518,000.00
	1.6m high, to be constructed on top of sheet pile wall	m	34	2,666.67	90,666.67
1.3	**1.2m high Retaining Wall**	m	116	950.61	110,271.05
1.4	**Quay Wall Type 5: Sheet pile wall**	m	250	4,768.25	1,192,062.50
	Timber cladding on dry side	m	131	50.00	6,550.00
1.5	**Handrail - 1.2m high**	m	43	500.00	21,500.00
1.6	**Non-return valves (wall)**	PS	1	30,300.00	30,300.00
1.7	**Regrading of existing road**	m2	164	96.50	15,816.35
1.8	**Regrading of existing footpath**	m2	311	41.09	12,787.97
1.9	**Embankment/Infill @ 1:10 gradient**	m	23	150.00	3,465.00
1.10	**Embankment/Infill @ 1:7 gradient**	m	212	150.00	31,725.00
1.11	**Embankment/Infill @ 1:1 gradient**	m	83	150.00	12,375.00
1.12	**Vehicle access ramp**	item	8	2,000.00	16,000.00
1.13	**Access steps**	item	3	5,000.00	15,000.00
1.14	**New footpath**	m2	284	41.09	11,649.71
1.15	**Landing, approximately 2.1 to 2.4m above EGL**	m2	107	41.09	4,413.33
1.16	**Landing, approximately 1 to 1.3m above EGL**	m2	314	41.09	12,886.59
1.17	**Backfill/land to be reclaimed**	m2	99	100.00	9,900.00
1.18	**Pumping station**	item	2	75,000.00	150,000.00
1.19	**Architectural Landscaping**	item	1	100,000.00	100,000.00
	Total				**2,611,577.80**

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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Dyke Parade**				
Option	**2 - Isolation of South Channel**				
1.1	**New Embankment - 18m wide @ 1:3 gradient, 2.55m high & 4m crown**	m	53	969.15	51,364.95
1.2	**New Embankment - 21m wide @ 1:3 gradient, 2.8m high & 4m crown**	m	219	1,084.40	237,483.60
1.3	**New Embankment - 10m wide @ 1:1 gradient, 2.5m high & 4m crown**	m	50	627.45	31,372.50
1.4	**New Embankment - 12.5m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	81	590.82	47,856.42
1.5	**Non-return valves (embankment)**	PS	1	4,000.00	4,000.00
1.6	**Relocation of existing fence to top of embankment**	m	131	75.00	9,825.00
1.7	**Regrading of existing footpath**	m2	297	41.09	12,200.35
1.8	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**469,102.82**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**2B - South of North Channel West Presentation School & Tyndall Institute** **2 - Isolation of South Channel**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall, to 1.7m above E.G.L.**	m	302	4,868.25	1,470,211.50
1.2	**Non-return valves (wall)**	PS	1	20,000.00	20,000.00
1.3	**Backfill/land to be reclaimed**	m3	3,322	30.00	99,645.00
1.4	**Footpath**	m2	1,062	41.09	43,640.18
1.5	**0.8m high Retaining Wall - Courtyard Area (incl Cladding and Railing)**	m	40	1,345.84	53,833.50
1.6	**0.6m high Retaining Wall - Non-Courtyard Area (incl Railing)**	m	70	1,190.54	83,337.63
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**1,845,667.80**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**3A - Kiln**				
Option	**2 - Isolation of South Channel**				
1.1	**Steel plate attached to existing North City**	m	141	750.00	105,750.00
1.2	**New concrete kerb on existing concrete access bridges**	m	15	1,068.63	16,029.38
1.3	**Replacement of existing timber/steel access bridges**	item	4	7,500.00	30,000.00
1.4	**Local defences fitted externally to double windows**	m	6	750.00	4,500.00
1.5	**Sealing existing building services/utilities**	sum	1	10,000.00	10,000.00
1.6	**Resealing of existing bridge joints**	item	11	1,000.00	11,000.00
	Total				**177,279.38**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East North Mall**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 3**	m	267	1,246.76	332,886.20
1.2	**Quay Wall Type 1**	m	249	2,550.43	635,055.83
1.3	**Relocation of existing historical railing to run along the inside of the footpath**	m	249	75.00	18,675.00
1.4	**Non-return valves**	PS	1	18,500.00	18,500.00
1.5	**Pumping station**	Item	1	75,000.00	75,000.00
1.6	**Regrading of existing road**	m2	1,739	96.50	167,765.25
1.7	**Regrading of existing footpath**	m2	745	41.09	30,593.32
	Total				**1,278,475.60**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East** **Pope's Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Quay Wall Type 1**	m	423	2,550.43	1,078,829.78
1.2	**Parapet Wall Type 1**	m	230	300.50	69,115.00
1.3	**Parapet Wall Type 2 - Infill of existing access to river access steps**	m	10	1,398.19	13,981.88
1.4	**Parapet Wall Type 5**	m	226	423.50	95,711.00
1.5	**Non Flood Defence Glass Wall**	m	15	500.00	7,500.00
1.6	**Non-return valves**	PS	1	16,000.00	16,000.00
1.7	**Pumping station**	item	1	75,000.00	75,000.00
1.8	**Access steps & gate**	item	2	3,000.00	6,000.00
1.9	**Regrading of existing footpath**	m2	76	41.09	3,123.03
	Total				**1,365,260.68**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East** **Camden Place**				
Option	**2 - Isolation of South Channel**				
1.1	**Quay Wall Type 1**	m	48	2,550.43	122,420.40
1.2	**Parapet Wall Type 1**	m	48	300.50	14,424.00
1.3	**Non-return valves**	PS	1	3,500.00	3,500.00
1.4	**Pumping Station**	m	1	75,000.00	75,000.00
	Total				**215,344.40**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East**				
	St Patricks Quay				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 4**	m	404	1,493.43	603,343.70
1.2	**Parapet Wall Type 3**	m	26	1,068.63	27,784.25
1.3	**Quay Wall Type 1**	m	302	2,550.43	770,228.35
1.4	**Non-return valves**	PS	1	29,500.00	29,500.00
1.5	**Pumping Station**	item	2	75,000.00	150,000.00
1.6	**Demountable steel flood gate**	No	2	11,000.00	22,000.00
	Total				**1,602,856.30**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East** **Penrose Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 4**	m	169	1,493.43	252,388.83
1.2	**Non-return valves**	PS	1	12,000.00	12,000.00
1.3	**Access steps & gate**	m	2.4	2,500.00	6,500.00
1.4	**Regrading of existing road**	m^2	1,105	96.50	106,593.90
1.5	**Regrading of existing footpath**	m^2	146	41.09	5,978.95
	Total				**383,461.68**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Grenville Place**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 2**	m	97	1,631.27	158,232.74
1.2	**Quay Wall Type 1**	m	97	2,550.43	247,391.23
1.3	**Non-return valves**	PS	1	7,000.00	7,000.00
1.4	**Demountable flood defence gate**	No.	2	11,000.00	22,000.00
1.5	**Regrading of existing road**	m2	2,107	96.50	203,354.45
1.6	**Regrading of existing footpath**	m2	654	41.09	26,878.57
	Total				**664,856.98**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Bachelors Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 2**	m	241	1,631.27	393,134.95
1.2	**Quay Wall Type 3**	m	211	3,354.67	707,835.77
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Non-return valves**	PS	1	14,500.00	14,500.00
1.5	**Regrading of existing road**	m^2	1,200	96.50	115,800.00
	Total				**1,306,270.72**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Griffith Bridge**				
Option	**2 - Isolation of South Channel**				
1.1	**New steel flood defence parapet**	m	95	1,125.00	106,875.00
	Total				**106,875.00**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Kryls Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 2**	m	213	1,398.19	297,813.94
1.2	**Quay Wall Type 1**	m	132	2,550.43	336,656.10
1.3	**Demountable steel flood gate**	No	1	11,000.00	11,000.00
1.4	**Non-return valves**	PS	1	11,500.00	11,500.00
1.5	**Regrading of existing road**	m2	2,971	41.09	122,073.32
	Total				**779,043.36**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East** **Coal Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 3**	m	155	1,068.63	165,636.88
1.2	**Quay Wall Type 1**	m	23	2,550.43	58,659.78
1.3	**Non-return valves**	PS	1	11,000.00	11,000.00
1.4	**Demountable steel flood gate**	No.	1	11,000.00	11,000.00
1.5	**Glass flood barrier**	m	14	2,000.00	28,000.00
1.6	**Pumping station**	item	1	150,000.00	150,000.00
1.7	**Access steps**	item	1	2,500.00	2,500.00
	Total				**426,796.65**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Lavitts Quay				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 5**	m	142	423.50	60,137.00
1.2	**Parapet Wall Type 1**	m	35	300.50	10,517.50
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Quay Wall Type 1**	m	42	2,550.43	107,117.85
1.5	**Quay Wall Type 2**	m	25	3,661.86	91,546.48
1.6	**Non-return valves**	PS	1	12,000.00	12,000.00
	Total				**356,318.83**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Christy Ring Bridge				
Option	**2 - Isolation of South Channel**				
1.1	**New steel flood defence parapet**	m	147	1,000.00	147,000.00
	Total				**147,000.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Merchants Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 4**	m	199	1,493.43	297,191.58
1.2	**Quay Wall Type 1**	m	33	2,550.43	84,164.03
1.3	**Non-return valves**	PS	1	2,500.00	2,500.00
1.4	**Pumping station**	item	2	150,000.00	300,000.00
	Total				**683,855.60**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Andersons Quay**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 4**	m	147	1,493.43	219,533.48
1.2	**Parapet Wall Type 5**	m	91	423.50	38,538.50
1.3	**Quay Wall Type 1**	m	84	2,550.43	214,235.70
1.4	**Non-return valves**	PS	1	16,500.00	16,500.00
1.5	**Pumping station**	item	1	75,000.00	75,000.00
1.6	**Demountable steel flood gate**	no.	2	11,000.00	22,000.00
	Total				**585,807.68**

Cost Estimate			Job No:		230436-00
			Sheet No:		**10**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East** **Brian Boru Bridge**				
Option	**2 - Isolation of South Channel**				
1.1	**Road reconstruction**	m	120	300.00	36,000.00
1.2	**Steel flood defense parapet**	m	124	1,000.00	123,800.00
	Total				**159,800.00**

Cost Estimate			Job No:		230436-00
			Sheet No:		**11**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Custom House St**				
Option	**2 - Isolation of South Channel**				
1.1	**Regrading of existing road**	m2	3,166	96.50	305,470.75
1.2	**Regrading of existing footpath**	m2	765	41.09	31,419.28
1.3	**Reinforced concrete retaining walls**	m	98	950.61	92,779.78
	Total				**429,669.81**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Victoria Rd**				
Option	**2 - Isolation of South Channel**				
1.1	**Regrading of existing road**	m2	2,026	96.50	195,537.95
1.2	**Regrading of existing footpath**	m2	465	41.09	19,112.10
	Total				**214,650.05**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East** **Albert Quay East**				
Option	**2 - Isolation of South Channel**				
1.1	**Parapet Wall Type 4**	m	136	1,493.43	203,105.80
1.2	**Footpath reinstatement**	m2	272	73.97	20,118.86
1.3	**Pumping station**	item	1	200,000.00	200,000.00
1.4	**Non-return valves**	PS	1	13,000.00	13,000.00
1.5	**Flow Isolation Structure**	LS	1	3,200,000.00	3,200,000.00
	Total				**3,636,224.66**

Cost Estimate				Job No:	230436-00
				Sheet No:	**1**
Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Curragheen**				
Option	**2 - Direct Defences and Flow Isolation in South Channel**				
1.1	**Flow Regulation Structure**	item	1	800,000.00	800,000.00
1.2	**3.0m high Retaining Wall**	m	22	2,846.07	62,613.54
1.3	**2.1m high Retaining Wall**	m	24	1,991.17	47,788.02
	Demolition of existing masonry wall	m3	13	75.00	1,008.00
1.4	**2.7m high Retaining Wall**	m	204	2,470.56	503,993.63
1.5	**Demolition of footbridge**	item	1	10,000.00	10,000.00
1.6	**3.2m high Retaining Wall**	m	39	3,112.51	121,387.97
1.7	**Flow Regulation Structure**	item	1	800,000.00	800,000.00
1.8	**New Culvert**	m	150	11,802.67	1,770,400.62
1.9	**Steel flood defence barrier at Bridge**	m	22	250.00	5,500.00
1.10	**3.0m high Retaining Wall**	m	50	2846.07	142,303.50
1.11	**3.0m Sheet Pile**	m	80	5,568.25	445,460.00
1.12	**3.0m high Retaining Wall**	m	35	2,846.07	99,612.45
1.13	**2.7m high Retaining Wall at Bridge**	m	22	2,470.56	53,116.98
1.14	**3.0m high Retaining Wall**	m	229	2,846.07	651,750.03
1.15	**Demolition of access bridge**	item	1	20,000.00	20,000.00
1.16	**2.9m high Embankment**	m	333	1,005.21	334,736.26
1.17	**1.8m high Embankment**	m	133	709.66	94,385.05
1.18	**2.2m high Embankment**	m	535	828.50	443,249.64
1.19	**Regrading of existing road**	m2	822	96.50	79,323.00
1.20	**Pumping Stations**	Item	2	75,000.00	150,000.00
	Total				**6,636,628.68**

Cost Estimate			Job No:	230436-00
			Sheet No:	**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Curragheen**				
Option	**2 - Direct Defences and Flow Isolation in South Channel**				
1.1	**3.2m high Retaining Wall**	m	22	3,112.51	68,475.26
1.2	**2.9m high Retaining Wall**	m	206	2,717.68	559,841.87
1.3	**3.2m high Retaining Wall**	m	36	3,112.51	112,050.43
1.4	**2.0m high Retaining Wall**	m	163	1,560.86	254,420.59
1.5	**2.8m high Retaining Wall**	m	153	2,592.51	396,653.72
1.6	**Pumping Stations**	item	2	75,000.00	150,000.00
	Total				**1,541,441.88**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Glasheen**				
Option	**2 - Direct Defences and Flow Isolation in South Channel**				
1.1	**Upgrade of Existing Culvert**	m	75	4,721.07	354080.1234
1.1	**2.2m high Retaining Wall**	m	9	1,991.17	17,920.51
	Demolition of existing masonry wall	m3	5	75.00	378.00
1.2	**2.8m high Retaining Wall**	m	92	2,592.51	238,510.74
1.1	**Upgrade of Existing Culvert**	m	9	4,721.07	42,489.61
1.3	**2.6m high Retaining Wall**	m	28	2,351.83	65,851.13
	Demolition of existing masonry wall	m3	16	75.00	1,176.00
1.4	**0.5m high Retaining Wall**	m	42	690.54	29,002.58
1.5	**2.8m high Retaining Wall**	m	120	2592.508	311,100.96
1.6	**Pumping Stations**	item	1	75,000.00	75,000.00
	Total				**781,429.52**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Glasheen**				
Option	**2 - Direct Defences and Flow Isolation in South Channel**				
1.1	**2.7m high Retaining Wall**	m	90	2,470.56	222,350.13
1.2	**2.8m high Retaining Wall**	m	115	2,592.51	298,138.42
1.3	**Pumping Stations**	item	1	75,000.00	75,000.00
	Total				**595,488.55**

B1.3 Option 3 – Direct Defences only

Project Title: Lower Lee Flood Relief Scheme		Job No:	230436-00
		Date:	December 2016
Area	**Area No**	**Element Name**	**Option 3 Direct Defences only**
Area 1			
West of Waterworks Weir	1A	Inniscarra	1,765,302
	1B	Ballincollig / Leemount	3,140,090
	1C	Inchigaggin/Carrigrohane Rd	3,310,483
	1D	Kingsley	1,082,767
	1E	Lee Road	637,000
		Sub-Total	**9,935,642**
Area 2: North Channel West			
North of North Channel West	2A	Lee Road	879,172
		Sunday's Well	1,811,919
		Distillery Fields	411,657
		Wise's Quay	431,362
South of North Channel West	2B	Salmon Weir	309,016
		Mardyke	1,083,410
		Fitzgerald's Park	100,000
		Dyke Parade	418,912
		Presentation School & Tyndall Institute	1,679,568
		Sub-Total	**7,125,015**
Area 3			
River Kiln	3	North City Link Rd	177,279
		Sub-Total	**177,279**
Area 4: North Channel East			
North of North Channel East	4A	North Mall	1,159,582
		Pope's Quay	1,357,288
		Camden Place	215,344
		St Patrick's Quay	1,584,510
		Penrose Quay	383,462
South of North Channel East	4B	Grenville Place	602,687
		Bachelor's Quay	1,165,858
		Griffith Bridge	79,164
		Kyrl's Quay	754,235
		Coal Quay	410,666
		Lavitt's Quay	351,309
		Christy Ring Bridge	110,250
		Merchant's Quay	671,463
		Anderson's Quay	584,201
		Brian Boru Bridge	153,610
		Custom House Street	429,670
		Sub-Total	**10,013,297**

Project Title: **Lower Lee Flood Relief Scheme**		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 3 Direct Defences only**
Area 5: South Channel East			
North of South Channel East	5A	Lapp's Quay East	311,100
		Clontarf Bridge	192,972
		Lapp's Quay West	681,723
		Morrison's Quay	1,781,447
		Father Mathew's Quay	1,046,773
		South Mall Properties	419,359
		Grand Parade Quay	497,877
		Dun Mhuire	114,203
		City Car Park	208,087
		Beamish and Crawford Yard	797,738
		Beamish and Crawford Yard	410,050
		Beamish and Crawford Yard	207,412
		Wandesford-Hanover St Properties	193,891
		Labour Exchange	334,592
		Waterside Quay	297,024
		Fisherman's Wharf	483,547
South of South Channel East	5B	Victoria Road	214,650
		Albert Quay East	397,238
		Albert Quay	791,479
		Terence MacSweeny Quay	272,252
		Union Quay	1,583,903
		George's Quay	441,564
		Sullivan's Quay	1,269,601
		French's Quay	375,194
		Crosse's Green Quay	880,335
		Wandesford Quay	645,034
		Crawford Hall	182,890
		Sub-Total	**15,031,934**

Project Title: **Lower Lee Flood Relief Scheme**		Job No:	230436-00
		Date:	**December 2016**
Area	**Area No**	**Element Name**	**Option 3** **Direct Defences only**
Area 6: South Channel West			
North of South Channel West	6A	St Finbarres Bridge	69,518
		Lancaster Quay	986,609
		Lancaster Lodge Bridge	24,238
		Hotel Bridge	24,238
		Inniscarrig Terrace	241,553
		Western Road	716,959
		Western Extent	836,515
South of South Channel West	6B	Mill Race Culvert	112,000
		Lancaster Lodge Quay	146,578
		Gill Abbey Branch and Glucksman	773,464
		Western Extent	749,057
		Sub-Total	**4,680,729**
Area 7: Curragheen/Glasheen			
	7	Curragheen	3,709,895
		Glasheen	761,600
		Sub-Total	**4,471,496**
		Grand Total	**51,435,392**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1A - Inniscarra**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	1531	828.50	1,268,439.62
1.2	**New Embankment - 18m wide @ 1:3 gradient, 2.55m high & 4m crown**	m	115	969.15	111,452.25
1.3	**New Embankment - 20m wide @ 1:3 gradient, 2.63m high & 4m crown**	m	78	1,005.21	78,406.69
1.4	**New Embankment - 10m wide @ 1:3 gradient, 1m high & 2m crown**	m	67	336.00	22,512.00
1.5	**Pumping station**	LS	3	75,000.00	225,000.00
1.6	**Vehicle access ramp**	No.	4	2,000.00	8,000.00
1.7	**Regrading of existing road**	m2	325	96.50	31,381.80
1.8	**Non-return valves (embankment)**	PS	1	20,110.00	20,110.00
	Total				**1,765,302.37**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1B - Ballincollig/Leemount**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 15m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	362	828.50	299,918.45
1.2	**New Embankment - 10m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	19	828.50	15,741.58
1.3	**New Embankment - 10m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	146	590.82	86,259.72
1.4	**1m high Retaining Wall**	m	41	845.05	34,647.05
1.5	**1.5m high Retaining Wall**	m	44	1,269.59	55,861.85
1.6	**0.6m high Retaining Wall**	m	71	690.54	49,028.16
1.7	**Sheet pile flood defence wall**	m	358	4,668.25	1,671,233.50
	Cladding to dry side (cladding to wet side incl. in sheet pile rate)	m2	358	100.00	35,800.00
1.8	**New 0.9m diameter concrete pipe culvert**	m	45	750.00	33,750.00
1.9	**Pumping station**	LS	4	75,000.00	300,000.00
1.10	**Land to be reclaimed**	m2	497	100.06	49,719.99
1.11	**Non-return valves (embankment)**	PS	1	2,500.00	2,500.00
1.12	**Regrading of existing road**	m2	374	96.50	36,129.60
1.13	**Cut off to Embankment**	m	313	1,500.00	469,500.00
	Total				**3,140,089.90**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1C - Carrigrohane Rd**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 18m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	2020	828.50	1,673,578.08
1.2	**New Embankment - 12.5m wide @ 1:3 gradient, 1.0m high & 4m crown**	m	618	590.82	365,126.76
1.3	**1.0m high Retaining Wall**	m	315	845.05	266,190.75
1.4	**Pumping station**	LS	4	75,000.00	300,000.00
1.5	**Vehicle access ramp**	item	11	2,000.00	22,000.00
1.6	**Connection of vehicle access ramp to existing footpath**	m2	583	50.00	29,130.00
1.7	**Road and turning area on top of embankment**	m2	779	50.00	38,970.00
1.8	**New carpark**	m2	2,524	125.00	315,487.50
1.9	**Cut off to embankment**	m	200	1,500.00	300,000.00
	Total				**3,310,483.09**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1D - Kingsley Area**				
Option	**3 - Direct Defences only**				
1.1	**1.3m high Retaining Wall**	m	248	1,188.64	294,783.34
	Capping beam + Cladding	m	248	200.00	49,600.00
1.2	**0.8m high Retaining Wall**	m	102	745.84	76,075.43
	0.6m high glass wall	m	102	1,000.00	102,000.00
1.3	**Removal and reinstatement of existing river wall and safety railing**	m	350	50.00	17,500.00
1.4	**Cut off to wall**	m	200	1,500.00	300,000.00
1.5	**Steps to maintain access**	no	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	233	96.50	22,465.20
1.7	**Regrading of existing footpath**	m2	1,250	41.09	51,365.56
1.8	**1.2m high Retaining Wall**	m	94	950.61	88,977.33
1.9	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,082,766.85**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**1E - Lee Road**				
Option	**3 - Direct Defences only**				
1.1	**Refurbishment/raising of existing embankment - 1:3 gradient side slopes & 2m crown**	m	363	336.00	121,968.00
1.2	**Refurbishment/raising of existing embankment - 1:2 gradient side slopes & 2m crown**	m	33	500.00	16,500.00
1.3	**Refurbishment/raising of existing embankment - 1:1 engineered side slopes & 2m crown**	m	87	1,000.00	87,000.00
1.4	**1.0m high Retaining Wall**	m	40	845.05	33,802.00
1.5	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.6	**Regrading of existing road**	m2	690	96.50	66,594.65
1.7	**Regrading of existing footpath**	m2	153	41.09	6,299.47
1.8	**Refurbish of existing masonry wall**	m	80	400.00	32,000.00
1.9	**1.0m high Retaining Wall**	m	82	845.05	69,294.10
1.10	**Vehicle access ramp**	item	1	2,000.00	2,000.00
1.11	**Pumping station**	item	2	75,000.00	150,000.00
1.12	**New culvert (2.0m wide by 1.2m high)**	m	20	1,927.07	38,541.37
1.13	**Replacement of Existing Sluice Valve**	item	1	8,000.00	8,000.00
	Total				**636,999.59**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Lee Road**				
Option	**3 - Direct Defences only**				
1.1	**0.8m high Retaining Wall**	m	216	745.84	161,100.90
	Coping + Cladding	m	648	100.00	64,800.00
	Reinstate existing roadway	m2	800	96.50	77,200.00
1.2	**1.1m high Retaining Wall**	m	82	928.21	76,113.43
	Cladding (random rubble limestone cladding)	m	82	100.00	8,200.00
	Footpath	m2	147.6	41.09	6,065.24
1.3	**Steel Flood Defence wall**	m	8	2,500.00	20,000.00
1.4	**Quay Wall Type 5: Sheet pile flood defence wall**	m	72	4,268.25	307,314.00
	timber cladding on dry side	m	72	50.00	3,600.00
1.5	**Non-return valves**	PS	1	30,500.00	30,500.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
1.7	**Vehicle access ramp**	m2	150	100.00	15,000.00
	Reinforced concrete wall to support ramp - 1.5m high	m	27	1,269.59	34,278.86
	Total				**879,172.43**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Sundays Well**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall**	m	361	4,318.25	1,558,888.25
	Cladding	m	361	100.00	36,100.00
	Reinstatement of footpath	m2	722	41.09	29,666.98
1.2	**1.65m high Retaining Wall**	m	37	1,560.86	57,751.91
	Cladding (random rubble cladding)	m	37	100.00	3,700.00
1.3	**Parapet Wall Type 1**	m	23	300.50	6,911.50
1.4	**Demolition of existing parapet wall**	m	252	75.00	18,900.00
1.5	**Non-return valves (wall)**	PS	1	25,000.00	25,000.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**1,811,918.64**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**2A - North of North Channel West Distillery Fields** **3 - Direct Defences only**				
1.1	**New Embankment - 6m wide @ 1:3 gradient, 0.35m high & 4m crown**	m	100	278.35	27,835.00
1.2	**New Embankment - 10m wide @ 1:3 gradient, 0.9m high & 4m crown**	m	254	396.60	100,736.40
1.3	**0.7m high Retaining Wall (incl fencing)**	m	218	793.44	172,969.38
1.4	**New reinforced concrete footbridge**	LS	1	80,000.00	80,000.00
1.5	**Proposed headwall and penstock**	LS	1	20,000.00	20,000.00
1.6	**Non-return valves (embankment)**	PS	1	5,000.00	5,000.00
1.7	**Regrading of existing footpath**	m2	125	41.09	5,116.01
	Total				**411,656.78**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2A - North of North Channel West Wises Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	74	990.34	73,284.88
1.2	**Railing**	m	17	500.00	8,500.00
1.3	**Quay Wall Type 1**	m	57	2,550.43	145,374.23
1.4	**Non-return valves (wall)**	PS	1	4,000.00	4,000.00
1.5	**Proposed penstock structure**	PS	1	30,000.00	30,000.00
1.6	**Remedial works to existing to ensure masonry arches can withstand uplift forces**	PS	1	31,000.00	31,000.00
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
1.8	**Regrading of existing road**	m2	170	96.50	16,405.00
1.9	**Regrading of existing footpath**	m2	25	41.09	1,027.31
1.10	**1.2m high Retaining Wall**	m	49	950.61	46,770.14
	Total				**431,361.55**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Salmon Weir Area**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 18m wide @ 1:3 gradient, 2.22m high & 4m crown**	m	84	828.50	69,594.34
1.2	**Regrading of existing footpath**	m2	623	41.09	25,588.27
1.3	**Demolition of existing wall**	m	40	100.00	4,000.00
1.4	**0.8m high Retaining Wall**	m	40	745.84	29,833.50
1.5	**Embankment Cut off**	m	120	1,500.00	180,000.00
	Total				**309,016.10**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Mardyke**				
Option	**3 - Direct Defences only**				
1.1	**1.1m high Retaining Wall**	m	61	928.21	56,620.96
1.2	**1.8m high Retaining Wall**	m	486	1,560.86	758,579.18
1.4	**Non-return valves (wall)**	PS	1	26,000.00	26,000.00
1.5	**Regrading of existing footpath**	m2	720	100.00	71,960.00
1.6	**Railing**	m	179	500.00	89,250.00
1.7	**Access steps**	item	1	5,000.00	5,000.00
1.8	**Pumping station**	item	1	75,000.00	75,000.00
1.9	**Security Gate**	item	1	1,000.00	1,000.00
	Total				**1,083,410.14**

Cost Estimate			Job No:		230436-00
			Sheet No:		**7**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Fitzgerald Park**				
Option	**3 - Direct Defences only**				
1.1	**0.7m high Retaining Wall**	m	259	723.44	187,370.31
1.2	**Glass flood defence wall**				
	1.2m high, to be constructed on top of retaining wall	m	259	2,000.00	518,000.00
	1.6m high, to be constructed on top of sheet pile wall	m	34	2,666.67	90,666.67
1.3	**1.2m high Retaining Wall**	m	116	950.61	110,271.05
1.4	**Quay Wall Type 5: Sheet pile wall**	m	250	4,268.25	1,067,062.50
	Timber cladding on dry side	m	131	50.00	6,550.00
1.5	**Handrail - 1.2m high**	m	43	500.00	21,500.00
1.6	**Non-return valves (wall)**	PS	1	30,300.00	30,300.00
1.7	**Regrading of existing road**	m2	164	96.50	15,816.35
1.8	**Regrading of existing footpath**	m2	311	41.09	12,787.97
1.9	**Embankment/Infill @ 1:10 gradient**	m	23	120.00	2,772.00
1.10	**Embankment/Infill @ 1:7 gradient**	m	212	120.00	25,380.00
1.11	**Embankment/Infill @ 1:1 gradient**	m	83	120.00	9,900.00
1.12	**Vehicle access ramp**	item	8	2,000.00	16,000.00
1.13	**Access steps**	item	3	5,000.00	15,000.00
1.14	**New footpath**	m2	284	41.09	11,649.71
1.15	**Landing, approximately 2.1 to 2.4m above EGL**	m2	107	41.09	4,413.33
1.16	**Landing, approximately 1 to 1.3m above EGL**	m2	314	41.09	12,886.59
1.17	**Backfill/land to be reclaimed**	m2	99	100.00	9,900.00
1.18	**Pumping station**	item	2	75,000.00	150,000.00
1.19	**Architectural Landscaping**	item	1	100,000.00	100,000.00
	Total				**2,418,226.47**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**2B - South of North Channel West Dyke Parade**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 12.5m wide @ 1:3 gradient, 1.35m high & 4m crown**	m	53	590.82	31,313.46
1.2	**New Embankment - 18m wide @ 1:3 gradient, 2.55m high & 4m crown**	m	219	969.15	212,243.85
1.3	**New Embankment - 10m wide @ 1:1 gradient, 2.15m high & 4m crown**	m	50	529.45	26,472.50
1.4	**New Embankment - 10m wide @ 1:3 gradient, 1.15m high & 4m crown**	m	81	590.82	47,856.42
1.5	**Non-return valves (embankment)**	PS	1	4,000.00	4,000.00
1.6	**Relocation of existing fence to top of embankment**	m	131	75.00	9,825.00
1.7	**Regrading of existing footpath**	m2	297	41.09	12,200.35
1.8	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**418,911.58**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**2B - South of North Channel West Presentation School & Tyndall Institute** **3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet pile flood defence wall, to 1.15m above E.G.L.**	m	302	4,318.25	1,304,111.50
1.2	**Non-return valves (wall)**	PS	1	20,000.00	20,000.00
1.3	**Backfill/land to be reclaimed**	m3	3,322	30.00	99,645.00
1.4	**Footpath**	m2	1,062	41.09	43,640.18
1.5	**0.8m high Retaining Wall - Courtyard Area (incl Cladding and Railing)**	m	40	1,345.84	53,833.50
1.6	**0.6m high Retaining Wall - Non-Courtyard Area (incl Railing)**	m	70	1,190.54	83,337.63
1.7	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**1,679,567.80**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**3A - Kiln**				
Option	**3 - Direct Defences only**				
1.1	**Steel plate attached to existing North City**	m	141	750.00	105,750.00
1.2	**New concrete kerb on existing concrete access bridges**	m	15	1,068.63	16,029.38
1.3	**Replacement of existing timber/steel access bridges**	item	4	7,500.00	30,000.00
1.4	**Local defences fitted externally to double windows**	m	6	750.00	4,500.00
1.5	**Sealing existing building services/utilities**	sum	1	10,000.00	10,000.00
1.6	**Resealing of existing bridge joints**	item	11	1,000.00	11,000.00
	Total				**177,279.38**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East North Mall**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 3**	m	267	801.47	213,992.16
1.2	**Quay Wall Type 1**	m	249	2,550.43	635,055.83
1.3	**Relocation of existing historical railing to run along the inside of the footpath**	m	249	75.00	18,675.00
1.4	**Non-return valves**	PS	1	18,500.00	18,500.00
1.5	**Pumping station**	Item	1	75,000.00	75,000.00
1.6	**Regrading of existing road**	m2	1,739	96.50	167,765.25
1.7	**Regrading of existing footpath**	m2	745	41.09	30,593.32
	Total				**1,159,581.56**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Pope's Quay**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 1**	m	423	2,550.43	1,078,829.78
1.2	**Parapet Wall Type 1**	m	230	300.50	69,115.00
1.3	**Parapet Wall Type 2 - Infill of existing access to river access steps**	m	10	1,398.19	13,981.88
1.4	**Parapet Wall Type 5**	m	226	388.22	87,738.27
1.5	**Non Flood Defence Glass Wall**	m	15	500.00	7,500.00
1.6	**Non-return valves**	PS	1	16,000.00	16,000.00
1.7	**Pumping station**	item	1	75,000.00	75,000.00
1.8	**Access steps & gate**	item	2	3,000.00	6,000.00
1.9	**Regrading of existing footpath**	m2	76	41.09	3,123.03
	Total				**1,357,287.95**

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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Camden Place**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 1**	m	48	2,550.43	122,420.40
1.2	**Parapet Wall Type 1**	m	48	300.50	14,424.00
1.3	**Non-return valves**	PS	1	3,500.00	3,500.00
1.4	**Pumping Station**	m	1	75,000.00	75,000.00
	Total				**215,344.40**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East**				
	St Patricks Quay				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**				
	0.6m high with 0.6m high railing	m	128	1,493.43	191,158.40
	0.55m high with 0.6m high railing	m	276	1,431.15	394,997.17
1.2	**Parapet Wall Type 3**	m	26	1,024.06	26,625.65
1.3	**Quay Wall Type 1**	m	302	2,550.43	770,228.35
1.4	**Non-return valves**	PS	1	29,500.00	29,500.00
1.5	**Pumping Station**	item	2	75,000.00	150,000.00
1.6	**Demountable steel flood gate**	No	2	11,000.00	22,000.00
	Total				**1,584,509.57**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4A - North of North Channel East Penrose Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	169	1,493.43	252,388.83
1.2	**Non-return valves**	PS	1	12,000.00	12,000.00
1.3	**Access steps & gate**	m	2.4	2,500.00	6,500.00
1.4	**Regrading of existing road**	m^2	1,105	96.50	106,593.90
1.5	**Regrading of existing footpath**	m^2	146	41.09	5,978.95
	Total				**383,461.68**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Grenville Place**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	97	990.34	96,062.61
1.2	**Quay Wall Type 1**	m	97	2,550.43	247,391.23
1.3	**Non-return valves**	PS	1	7,000.00	7,000.00
1.4	**Demountable flood defence gate**	No.	2	11,000.00	22,000.00
1.5	**Regrading of existing road**	m2	2,107	96.50	203,354.45
1.6	**Regrading of existing footpath**	m2	654	41.09	26,878.57
	Total				**602,686.85**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Bachelors Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	241	1,048.64	252,722.39
1.2	**Quay Wall Type 3**	m	211	3,354.67	707,835.77
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Non-return valves**	PS	1	14,500.00	14,500.00
1.5	**Regrading of existing road**	m^2	1,200	96.50	115,800.00
	Total				**1,165,858.16**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Griffith Bridge**				
Option	**3 - Direct Defences only**				
1.1	**New steel flood defence parapet**	m	95	833.30	79,163.50
	Total				**79,163.50**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Kryls Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	213	1,281.72	273,006.04
1.2	**Quay Wall Type 1**	m	132	2,550.43	336,656.10
1.3	**Demountable steel flood gate**	No	1	11,000.00	11,000.00
1.4	**Non-return valves**	PS	1	11,500.00	11,500.00
1.5	**Regrading of existing road**	m2	2,971	41.09	122,073.32
	Total				**754,235.46**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Coal Quay				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 3**	m	155	979.61	151,839.32
1.2	**Quay Wall Type 1**	m	23	2,550.43	58,659.78
1.3	**Non-return valves**	PS	1	11,000.00	11,000.00
1.4	**Demountable steel flood gate**	No.	1	11,000.00	11,000.00
1.5	**Glass flood barrier, 1.1m high**	m	14	1,833.33	25,666.67
1.6	**Pumping station**	item	1	150,000.00	150,000.00
1.7	**Access steps**	item	1	2,500.00	2,500.00
	Total				**410,665.76**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East**				
	Lavitts Quay				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 5**	m	142	388.22	55,127.59
1.2	**Parapet Wall Type 1**	m	35	300.50	10,517.50
1.3	**Pumping station**	item	1	75,000.00	75,000.00
1.4	**Quay Wall Type 1**	m	42	2,550.43	107,117.85
1.5	**Quay Wall Type 2**	m	25	3,661.86	91,546.48
1.6	**Non-return valves**	PS	1	12,000.00	12,000.00
	Total				**351,309.42**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Christy Ring Bridge**				
Option	**3 - Direct Defences only**				
1.1	**New steel flood defence parapet**	m	147	750.00	110,250.00
	Total				**110,250.00**

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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Merchants Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	199	1,431.15	284,798.69
1.2	**Quay Wall Type 1**	m	33	2,550.43	84,164.03
1.3	**Non-return valves**	PS	1	2,500.00	2,500.00
1.4	**Pumping station**	item	2	150,000.00	300,000.00
	Total				**671,462.71**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Andersons Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	147	1,493.43	219,533.48
1.2	**Parapet Wall Type 5**	m	91	405.84	36,931.44
1.3	**Quay Wall Type 1**	m	84	2,550.43	214,235.70
1.4	**Non-return valves**	PS	1	16,500.00	16,500.00
1.5	**Pumping station**	item	1	75,000.00	75,000.00
1.6	**Demountable steel flood gate**	no.	2	11,000.00	22,000.00
	Total				**584,200.62**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East** **Brian Boru Bridge**				
Option	**3 - Direct Defences only**				
1.1	**Road reconstruction**	m	120	300.00	36,000.00
1.2	**New steel flood defence parapet, 0.4 high**	m	124	950.00	117,610.00
	Total				**153,610.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**4B - South of North Channel East Custom House St**				
Option	**3 - Direct Defences only**				
1.1	**Regrading of existing road**	m2	3,166	96.50	305,470.75
1.2	**Regrading of existing footpath**	m2	765	41.09	31,419.28
1.3	**Reinforced concrete retaining walls**	m	98	950.61	92,779.78
	Total				**429,669.81**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East**				
	Lapps Quay East				
Option	**3 - Direct Defences only**				
1.1	**Glass flood defence wall**	m	78	2,000.00	156,000.00
1.2	**Demountable steel access gate**	item	2	11,268.00	22,536.00
1.3	**Steel flip-up flood barrier**	item	3	44,188.00	132,564.00
	Total				**311,100.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Clontarf Bridge**				
Option	**3 - Direct Defences only**				
1.1	**Road reconstruction**	m	123	300.00	36,900.00
1.2	**Steel flood defence upstand**	m	111	1,000.00	111,000.00
1.3	**Demountable steel flood gate**	no.	4	11,268.00	45,072.00
	Total				**192,972.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Lapps Quay West**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	103	1,493.43	153,822.78
1.2	**Quay Wall Type 1**	m	103	2,550.43	262,693.78
1.3	**Non-return valves**	PS	1	7,500.00	7,500.00
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Regrading of existing road**	m2	1,555	96.50	150,009.25
1.6	**Public bike share docking station to be temporily removed and re-instated following raising of existing ground**	LS	1	20,000.00	20,000.00
1.7	**Footpath**	m2	309	41.09	12,697.57
	Total				**681,723.37**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Morrisons Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	321	1,493.43	479,389.43
1.2	**Quay Wall Type 1**	m	330	2,550.43	841,640.25
1.3	**Non-return valves**	PS	1	23,000.00	23,000.00
1.4	**Road regrading / resurfacing**	m2	2,564	96.50	247,426.00
1.5	**Pumping Station**	item	2	75,000.00	150,000.00
1.6	**Steel flip-up flood barrier**	item	1	39,991.00	39,991.00
	Total				**1,781,446.68**

Cost Estimate		Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**	Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East**				
	Fr Mathews Quay				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	222	1,493.43	331,540.35
1.2	**Quay Wall Type 1**	m	222	2,550.43	566,194.35
1.3	**Non-return valves**	PS	1	15,000.00	15,000.00
1.4	**Road regrading / resurfacing**	m2	1,389	96.50	134,038.50
	Total				**1,046,773.20**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East** **South Mall Properties**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet pile wall**	m	58	4,668.25	270,758.50
1.2	**Removal of section of existing boardwalk**	m	6	500.00	3,000.00
1.3	**Pedestrian access ramp/boardwalk (incl retaining wall, privacy barrier and railing)**	item	1	145,600.00	145,600.00
	Total				**419,358.50**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Grand Parade Quay**				
Option	**3 - Direct Defences only**				
1.1	**Steel flip-up flood barrier**	PS	5	44,188.00	350,000.00
1.2	**Proposed reinforced concrete wall (incl wooden finish)**	m	72	945.05	68,043.60
1.3	**0.6m high reinforced concrete retaining wall**	m	7	690.54	4,833.76
1.4	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**497,877.36**

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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Dun Mhuire**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 1**	m	36	2,550.43	91,815.30
1.2	**Parapet Wall Type 5**	m	8	423.50	3,388.00
1.3	**Waterproofing Works to Building**	PS	1	19,000.00	19,000.00
	Total				**114,203.30**

Cost Estimate			Job No:		230436-00
			Sheet No:		**9**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East City Car Park**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 5 (incl railing)**	m	51	523.50	26,698.50
1.2	**Parapet Wall Type 1**	m	18	300.50	5,409.00
1.3	**Quay Wall Type 2**	m	69	2,550.43	175,979.33
	Total				**208,086.83**

Cost Estimate			Job No:		230436-00
			Sheet No:		**10**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford Yard**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	150	5,318.25	797,737.50
	Total				**797,737.50**

Cost Estimate			Job No:		230436-00
			Sheet No:		**11**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	63	5,318.25	335,049.75
1.2	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**410,049.75**

Cost Estimate			Job No:		230436-00
			Sheet No:		**12**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Beamish & Crawford Kegging**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	39	5,318.25	207,411.75
	Total				**207,411.75**

Cost Estimate			Job No:		230436-00
			Sheet No:		**13**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East**				
	Wandesford-Hanover St Properties				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	18	1,617.83	29,120.89
1.2	**Raising of flood defence along balcony (steel plates)**	m	15	550.00	8,250.00
1.3	**Quay Wall Type 4**	m	41	3,817.56	156,520.06
	Total				**193,890.95**

Cost Estimate			Job No:		230436-00
			Sheet No:		**14**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Labour Exchange**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	63	1,493.43	94,085.78
1.2	**Quay Wall Type 4**	m	63	3,817.56	240,506.44
	Total				**334,592.21**

Cost Estimate			Job No:		230436-00
			Sheet No:		**15**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Waterside Quay**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing and cladding)**	m	55	5,318.25	292,503.75
1.2	**Footpath**	**m2**	**110**	**41.09**	**4,520.17**
	Total				**297,023.92**

Cost Estimate			Job No:		230436-00
			Sheet No:		**16**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5A - North of South Channel East Fishermans Wharf**				
Option	**3 - Direct Defences only**				
1.1	**Quay Wall Type 5: Sheet Pile Wall (incl railing)**	m	91	5,313.70	483,547.11
	Total				**483,547.11**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Victoria Rd**				
Option	**3 - Direct Defences only**				
1.1	**Regrading of existing road**	m2	2,026	96.50	195,537.95
1.2	**Regrading of existing footpath**	m2	465	41.09	19,112.10
	Total				**214,650.05**

Cost Estimate			Job No:		230436-00
			Sheet No:		**2**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East**				
	Albert Quay East				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	175	1,493.43	261,349.38
1.2	**Footpath reinstatement**	m2	350	73.97	25,888.24
1.3	**Steel flood defence barrier**	No.	2	11,000.00	22,000.00
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Non-return valves**	PS	1	13,000.00	13,000.00
	Total				**397,237.62**

Cost Estimate			Job No:		230436-00
			Sheet No:		**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East**				
	Albert Quay				
Option	**3 - Direct Defences only**				
1.1	**Demolition and disposal of existing wharf**	PS	1	50,000.00	50,000.00
1.2	**Quay Wall Type 5: Sheet Pile Wall (incl railing & cladding)**	m	91	5,268.25	479,410.75
	Extra over for concrete infill	m3	2134	80.00	170,720.00
1.3	**Footpath**	m2	228	41.09	9,348.53
1.4	**Pumping station**	item	1	75,000.00	75,000.00
1.5	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**791,479.28**

Cost Estimate			Job No:		230436-00
			Sheet No:		**4**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East**				
	Terence MacSweeny Quay				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	93	1,493.43	138,888.53
1.2	**Regrading of existing road**	m	1,226	96.50	118,309.00
1.3	**Regrading of existing footpath**	m	196	41.09	8,054.12
1.4	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**272,251.64**

Cost Estimate			Job No:		230436-00
			Sheet No:		**5**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Union Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 3**	m	271	1,068.63	289,597.38
1.2	**Quay Wall Type 3**	m	303	3,354.67	1,016,465.58
1.3	**Glass flood defence wall**	m	30	2,000.00	60,000.00
1.4	**Steel flip up flood defence barrier**	item	1	39,991.00	39,991.00
1.5	**Non-return valves**	PS	1	26,000.00	26,000.00
1.6	**Pumping station**	item	1	150,000.00	150,000.00
1.7	**Regrading of existing footpath**	m2	45	41.09	1,849.16
	Total				**1,583,903.11**

Cost Estimate			Job No:		230436-00
			Sheet No:		**6**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Georges Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 3**	m	78	1,068.63	83,352.75
1.2	**Parapet Wall Type 4**	m	142	1,493.43	212,066.35
1.3	**Glass flood defence wall**	m	20	2,000.00	40,000.00
1.4	**Non-return valves**	PS	1	17,000.00	17,000.00
1.5	**Extension of access steps**	m	6	2,500.00	15,000.00
	0.8m high guard rail	m	15	500.00	7,250.00
	Access gate	item	1	300.00	300.00
1.6	**Existing footpath to be reinstated and extended**	m2	484	41.09	19,888.74
1.7	**Existing road to be reinstated**	m3	484	96.50	46,706.00
					0.00
	Total				**441,563.84**

	Cost Estimate			Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Sullivans Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 4**	m	229	1,493.43	341,994.33
1.2	**Quay Wall Type 3**	m	233	3,354.67	781,638.55
1.3	**Non-return valves**	PS	1	16,000.00	16,000.00
1.4	**Demountable pedestrian access gate**	item	1	46,568.00	46,568.00
1.5	**Pumping station**	item	1	75,000.00	75,000.00
1.6	**Extension of access steps**	item	1	2,500.00	2,500.00
	Guard rail	m	11	500.00	5,400.00
	Access gate	item	1	500.00	500.00
	Total				**1,269,600.87**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Frenchs Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 1**	m	122	300.50	36,661.00
1.2	**Quay Wall Type 1**	m	92	2,550.43	234,639.10
1.3	**Quay Wall Type 4**	m	2	3,817.56	7,635.13
1.4	**Demountable pedestrian access gate**	item	1	12,759.00	12,759.00
1.5	**Culvert repair works**	PS	1	75,000.00	75,000.00
1.6	**Non-return valves**	PS	1	8,500.00	8,500.00
	Total				**375,194.23**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area **Option**	**5B - South of South Channel East Crosses Green Quay** **3 - Direct Defences only**				
1.1	**Demolition of existing concrete parapet**	m	145	75.00	10,875.00
1.2	**Quay Wall Type 5: Sheet Pile Wall**	m	145	5,168.25	749,396.25
1.3	**Cladding: 150mm random rubble limestone, dry side only as wet side cladding covered in Sheet Pile Wall Rate**	m2	79	100.00	7,900.00
1.4	**Existing footpath to be reinstated and extended**	m2	290	41.09	11,916.81
1.5	**Existing road to be reinstated**	m3	158	96.50	15,247.00
1.6	**Pumping station**	item	1	75,000.00	75,000.00
1.7	**Non-return valves**	PS	1	10,000.00	10,000.00
	Total				**880,335.06**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Wandesford Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	105	1,514.66	159,038.93
1.2	**Quay Wall Type 2**	m	105	3,661.86	384,495.23
1.3	**Non-return valves**	PS	1	6,500.00	6,500.00
1.4	**Temporary removal and reinstatement of bicycle scheme**	LS	1	20,000.00	20,000.00
1.5	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**645,034.17**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**5B - South of South Channel East Crawford Hall**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	63	1,514.66	95,423.36
1.2	**Glass flood defence wall**	m	37	2,166.67	80,166.67
1.3	**Demolition of existing railing**	m	20	40.00	800.00
1.4	**Non-return valves**	PS	1	6,500.00	6,500.00
	Total				**182,890.03**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West**				
	St Finbarres Bridge				
Option	**3 - Direct Defences only**				
1.1	**Demolish existing railing**	m	60	40.00	2,400.00
1.2	**Parapet Wall Type 3**	m	60	1,068.63	64,117.50
	Extra over for doweling into bridge deck	m	60	50.00	3,000.00
	Total				**69,517.50**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Lancaster Quay**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	12	1,398.19	16,778.25
1.2	**Parapet Wall Type 1**	m	97	300.50	29,148.50
1.3	**Parapet Wall Type 5**	m	143	423.50	60,560.50
1.4	**Quay Wall Type 3**	m	240	3,354.67	805,121.25
1.5	**Pumping station**	item	1	75,000.00	75,000.00
	Total				**986,608.50**

Cost Estimate			Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West**				
	Lancaster Lodge Brdge				
Option	**3 - Direct Defences only**				
1.1	**Demolish existing railing**	m	17	40.00	680.00
1.2	**Parapet Wall Type 3**	m	17	1,335.78	22,708.28
	Extra over for doweling into bridge deck	m	17	50.00	850.00
	Total				**24,238.28**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Hotel Bridge**				
Option	**3 - Direct Defences only**				
1.1	**Demolish existing railing**	m	17	40.00	680.00
1.2	**Parapet Wall Type 3**	m	17	1,335.78	22,708.28
	Extra over for doweling into bridge deck	m	17	50.00	850.00
	Total				**24,238.28**

Cost Estimate				Job No:	230436-00
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Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West**				
	Inniscarrig Terrace				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 2**	m	8	1,747.73	13,981.88
1.2	**Parapet Wall Type 1**	m	29	300.50	8,714.50
1.3	**Quay Wall Type 5: Sheet Pile Wall**	m	17	5,168.25	87,860.25
1.4	**New Embankment, 2m wide crest**	m	141	340.40	47,996.40
1.5	**Non-return valves**	PS	1	8,000.00	8,000.00
1.6	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**241,553.03**

Cost Estimate			Job No:		230436-00
			Sheet No:		**6**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6A - North of South Channel West Western Road**				
Option	**3 - Direct Defences only**				
1.1	**Demolition of existing steel fencing**	m	56	40.00	2,240.00
1.2	**Retaining Wall - 1.05m high**	m	56	845.05	47,322.80
1.3	**Retaining Wall - 1.25m high**	m	50	1,188.64	59,432.13
1.4	**Railing**	m	97	100.00	9,700.00
1.5	**Parapet Wall Type 5**	m	49	423.50	20,751.50
1.6	**Quay Wall Type 5 - Sheet Pile Wall**	m	107	5,418.25	579,752.75
	Total				**716,959.18**

Cost Estimate			Job No:	230436-00
			Sheet No:	**7**
Project Title	**Lower Lee Flood Relief Scheme**		Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West Western Extent of Southern Channel North**				
Option	**3 - Direct Defences only**				
1.1	**0.9m high Retaining Wall**	m	155	827.90	128,324.50
1.2	**1.0m high Retaining Wall**	m	105	845.05	88,730.25
1.3	**1.4m high Retaining Wall**	m	35	1,184.91	41,471.71
1.4	**1.5m high Retaining Wall**	m	360	1,269.59	457,051.50
1.5	**2.5m high Retaining Wall**	m	105	2,164.40	227,261.90
1.6	**Demountable Steel Gates, 1.65m high**	no.	2	11,000.00	22,000.00
	Total				**836,515.36**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West**				
	Mill Race Culvert				
Option	**3 - Direct Defences only**				
1.1	**Culvert repair works (5m wide)**	m	105	1,000.00	105,000.00
1.2	**Non-return valves**	PS	1	7,000.00	7,000.00
	Total				**112,000.00**

Cost Estimate			Job No:		230436-00
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Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West Lancaster Lodge Qy**				
Option	**3 - Direct Defences only**				
1.1	**0.9m high Retaining Wall**	m	10	827.90	8,279.00
1.2	**0.4m high Retaining Wall**	m	66	460.38	30,385.17
1.3	**Railing**	m	10	500.00	5,000.00
1.4	**Non-return valves**	PS	1	5,000.00	5,000.00
1.5	**Existing structure to be sealed**	PS	1	5,000.00	5,000.00
1.6	**0.35m high Retaining Wall (incl railing)**	m	105	401.12	42,117.84
1.7	**0.15m high concrete kerb (incl railing)**	m	111	457.63	50,796.38
	Total				**146,578.39**

Cost Estimate			Job No:		230436-00
			Sheet No:		**10**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West Gill Abbey Branch and Glucksman**				
Option	**3 - Direct Defences only**				
1.1	**New Embankment - 20m wide @ 1:3 gradient, 2.75m high & 4m crown**	m	150	1,005.21	150,782.10
1.2	**2.75m high Retaining Wall**	m	225	2,380.84	535,688.77
1.3	**New Embankment - 10m wide @ 1:3 gradient, 1.1m high & 4m crown**	m	105	828.50	86,992.92
	Total				**773,463.79**

Cost Estimate			Job No:		230436-00
			Sheet No:		**11**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**6B - South of South Channel West Western Extent of Southern Channel South**				
Option	**3 - Direct Defences only**				
1.1	**1.0m high Retaining Wall**	m	190	845.05	160,559.50
1.2	**1.5m high Retaining Wall**	m	132	1,269.59	167,585.55
1.3	**2.3m high Retaining Wall**	m	133	1,991.17	264,825.28
1.4	**1.8m high Retaining Wall**	m	100	1,560.86	156,086.25
	Total				**749,056.58**

Cost Estimate			Job No:		230436-00
			Sheet No:		**1**
Project Title	**Lower Lee Flood Relief Scheme**		Date:		**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Curragheen**				
Option	**3 - Direct Defences only**				
1.1	**0.7m high Retaining Wall**	m	330	723.44	238,734.38
1.2	**Parapet wall type 1**	m	24	300.50	7,212.00
1.3	**1.2m high Retaining Wall**	m	204	950.61	193,924.95
1.4	**Demolition of footbridge**	item	1	10,000.00	10,000.00
1.5	**2m high Retaining Wall**	m	39	1,991.17	77,655.53
1.6	**Steel flood defence parapet at Bridge**	m	22	250.00	5,500.00
1.7	**2.1m high Retaining Wall**	m	50	1,991.17	99,558.38
1.8	**2.1m Sheet Pile**	m	80	4,668.25	373,460.00
1.9	**2.1m high Retaining Wall**	m	35	1,991.17	69,690.86
1.10	**1.7m high Retaining Wall**	m	22	1,560.86	33,558.54
1.11	**2.1m high Retaining Wall**	m	229	1,991.17	455,977.36
1.12	**Demolition of access bridge**	item	1	20,000.00	20,000.00
1.13	**2.5m high Embankment**	m	333	969.15	322,726.95
1.14	**1.4m high Embankment**	m	133	590.82	78,579.06
1.15	**1.8m high Embankment**	m	535	709.66	379,669.17
1.16	**Regrading of existing road**	m2	822	96.50	79,323.00
1.17	**Pumping Station**	Item	2	75,000.00	150,000.00
	Total				**2,595,570.18**

Cost Estimate				Job No:	230436-00
				Sheet No:	**2**
Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Curragheen**				
Option	**3 - Direct Defences only**				
1.1	**0.6m high Retaining Wall**	m	349	690.54	240,997.59
1.2	**1.45m high Retaining Wall**	m	206	1,269.59	261,535.03
1.3	**2m high Retaining Wall**	m	36	1,991.17	71,682.03
1.4	**1.1m high Retaining Wall**	m	163	928.21	151,298.64
1.5	**1.8m high Retaining Wall**	m	153	1,560.86	238,811.96
1.6	**Pumping Station**	item	2	75,000.00	150,000.00
	Total				**1,114,325.24**

Cost Estimate			Job No:	230436-00
			Sheet No:	**3**
Project Title	**Lower Lee Flood Relief Scheme**		Date:	**December 2016**

Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Glasheen**				
Option	**3 - Direct Defences only**				
1.1	**Parapet Wall Type 1**	m	9	300.50	2,704.50
1.2	**0.9m high Retaining Wall**	m	92	827.90	76,166.80
1.3	**Parapet Wall Type 1**	m	28	300.50	8,414.00
1.4	**1.5m high Retaining Wall**	m	120	1,269.59	152350.5
1.5	**Pumping Station**	item	1	75,000.00	75,000.00
	Total				**314,635.80**

Cost Estimate				Job No:	230436-00
				Sheet No:	**4**
Project Title	**Lower Lee Flood Relief Scheme**			Date:	**December 2016**
Number	Item Description	Unit	Quantity	Rate €	Total €
Area	**7 - Glasheen**				
Option	**3 - Direct Defences only**				
1.1	**0.9m high Retaining Wall**	m	42	827.90	34,771.80
1.2	**1.3m high Retaining Wall**	m	22	1,188.64	26,150.14
1.3	**1.8m high Retaining Wall**	m	26	1,560.86	40,582.43
1.4	**2.6m high Retaining Wall**	m	115	2,351.83	270,459.99
1.5	**Pumping Stations**	item	1	75,000.00	75,000.00
	Total				**446,964.35**

B2 Cost-Benefit Analysis

Lower Lee FRS CBA

4% Discount Rate

Client/Authority		
Office of Public Works		
Project name		
Lower Lee (Cork City) Drainage Scheme		
Project reference		
Base date for estimates (year 0)	Jan-2017	
Scaling factor (e.g. £m, £k, £)	Euro, m	(used for all costs, losses and benefits)
Discount rate	4.0%	

Prepared (date)	09/12/2016
Printed	
Prepared by	KB/DS/KL
Checked by	KL
Checked date	

Costs and benefits of options

	Costs and benefits Euro, m				
	Do Nothing	Preferred Scheme Option			
PV costs PVc	0.000	128.45			
PV damage PVd	273.649	88.192			
PV damage avoided		185.457			
PV assets Pva	-	0.000			
PV asset protection benefits		0.000			
Total PV benefits PVb		185.457			
Net Present Value NPV		57.010			
Average benefit/cost ratio		1.444			

Brief description of options:

Do Nothing	No Maintenance of Defences
Emerging Preferred Option	Standard of Protection 1 in 100 year fluvial / 1 in 200 year tidal

Notes:

1) Benefits will normally be expressed either in terms of damage avoided or asset values protected. Care is needed to avoid double counting

2) PV damage avoided is calculated as PV damage (No Project) - PV damage (Option)
PV asset protection benefits are calculated as PVa (Option) - PVa (No Project)
PV benefits calculated as PV damage avoided + PV asset protection benefits

3) Incremental benefit/cost ratio is calculated as:
(PVb(current option) - PVb(previous option))/(PVc(current option) - PVc(previous option))

Lower Lee FRS CBA
3% Discount Rate

Client/Authority	Prepared (date)	09/12/2016
Office of Public Works	Printed	
Project name	Prepared by	KB/DS/KL
Lower Lee (Cork City) Drainage Scheme	Checked by	KL
Project reference	Checked date	

Base date for estimates (year 0)	Jan-2017	
Scaling factor (e.g. £m, £k, £)	Euro, m	(used for all costs, losses and benefits)
Discount rate	3.0%	

Costs and benefits of options

	Costs and benefits Euro, m				
	Do Nothing	Preferred Scheme Option			
PV costs PVc	0.000	128.45			
PV damage PVd	328.819	104.614			
PV damage avoided		224.205			
PV assets Pva	-	0.000			
PV asset protection benefits		0.000			
Total PV benefits PVb		224.205			
Net Present Value NPV		95.758			
Average benefit/cost ratio		1.746			

Brief description of options:

Do Nothing	No Maintenance of Defences
Emerging Preferred Option	Standard of Protection 1 in 100 year fluvial / 1 in 200 year tidal

Notes:

1) Benefits will normally be expressed either in terms of damage avoided or asset values protected. Care is needed to avoid double counting

2) PV damage avoided is calculated as PV damage (No Project) - PV damage (Option)
PV asset protection benefits are calculated as PVa (Option) - PVa (No Project)
PV benefits calculated as PV damage avoided + PV asset protection benefits

3) Incremental benefit/cost ratio is calculated as:
(PVb(current option) - PVb(previous option))/(PVc(current option) - PVc(previous option))

Lower Lee FRS CBA

5% Discount Rate

Client/Authority		Prepared (date)	09/12/2016
Office of Public Works		Printed	
Project name		Prepared by	KB/DS/KL
Lower Lee (Cork City) Drainage Scheme		Checked by	KL
Project reference		Checked date	
Base date for estimates (year 0)	Jan-2017		
Scaling factor (e.g. £m, £k, £)	Euro, m	(used for all costs, losses and benefits)	
Discount rate	5.0%		

Costs and benefits of options

	Costs and benefits Euro, m				
	Do Nothing	Preferred Scheme Option			
PV costs PVc	0.000	128.45			
PV damage PVd	231.573	75.667			
PV damage avoided		155.906			
PV assets Pva	-	0.000			
PV asset protection benefits		0.000			
Total PV benefits PVb		155.906			
Net Present Value NPV		27.459			
Average benefit/cost ratio		1.214			

Brief description of options:

Do Nothing	No Maintenance of Defences
Emerging Preferred Option	Standard of Protection 1 in 100 year fluvial / 1 in 200 year tidal

Notes:

1) Benefits will normally be expressed either in terms of damage avoided or asset values protected. Care is needed to avoid double counting

2) PV damage avoided is calculated as PV damage (No Project) - PV damage (Option)
PV asset protection benefits are calculated as PVa (Option) - PVa (No Project)
PV benefits calculated as PV damage avoided + PV asset protection benefits

3) Incremental benefit/cost ratio is calculated as:
(PVb(current option) - PVb(previous option))/(PVc(current option) - PVc(previous option))

Lower Lee FRS CBA

4% Discount Rate

Client/Authority		Prepared (date)	09/12/2016
Office of Public Works		Printed	
Project name		Prepared by	KB/DS/KL
Lower Lee (Cork City) Drainage Scheme		Checked by	KL
Project reference		Checked date	
Base date for estimates (year 0)	Jan-2017		
Scaling factor (e.g. £m, £k, £)	Euro, m	(used for all costs, losses and benefits)	
Discount rate	4.0%		

Costs and benefits of options

	Costs and benefits Euro, m				
	Do Nothing	Preferred Scheme Option			
PV costs PVc	0.000	128.45			
PV damage PVd	273.649	88.192			
PV damage avoided		185.457			
PV assets Pva	-	0.000			
PV asset protection benefits		0.000			
Total PV benefits PVb		176.184			
Net Present Value NPV		47.737			
Average benefit/cost ratio		1.372			

Brief description of options:

Do Nothing	No Maintenance of Defences
Emerging Preferred Option	Standard of Protection 1 in 100 year fluvial / 1 in 200 year tidal

Notes:

1) Benefits will normally be expressed either in terms of damage avoided or asset values protected. Care is needed to avoid double counting

2) PV damage avoided is calculated as PV damage (No Project) - PV damage (Option)
PV asset protection benefits are calculated as PVa (Option) - PVa (No Project)
PV benefits calculated as PV damage avoided + PV asset protection benefits

3) Incremental benefit/cost ratio is calculated as:
(PVb(current option) - PVb(previous option))/(PVc(current option) - PVc(previous option))

Appendix C

Multi-Criteria Assessment of Options

C1 MCA Objectives and Targets

Core Criteria	Objective	Sub objective	Code	Indicator	Basic Requirement	Aspirational Target
Technical	Ensure flood risk management options are operationally robust	"	1.A.	Level of operational risk of option - Degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, for the option to operate or perform successfully	Moderate to high, but manageable, degree of operational risk, i.e., an option with a high degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, but which, with the allocation of adequate resources, could be operated with an acceptable degree of risk of failure	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully
	Minimise health and safety risk in construction and operation of the flood risk management option	"	1.B	Degree of health and safety risk during construction and operation	Moderate to high, but acceptable and manageable, level of health and safety risk during either construction or operation	Negligible risk to health and safety during either construction or operation
	Ensure flood risk can be managed effectively and sustainably into the future	"	1.C	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change	Option to provide for, or be adaptable to, the MRFS in terms of maintaining the standard of protection at acceptable cost	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection at negligible cost
Economic	Reduce economic damage	"	2.A	Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits	AAD is not increased	100% reduction in AAD
	Minimise risk to transport infrastructure	"	2.B	Number and type of transport routes at risk from flooding	No increase in risk to transport infrastructure	Reduce risk to transport infrastructure to zero
	Minimise risk to utilities infrastructure	"	2.C	Number and type of infrastructure assets at risk from flooding	No increase in risk to utility infrastructure	Reduce risk to utility infrastructure to zero
	Minimise risk to agriculture	"	2.D	Agricultural production	No increase in the negative impact of flooding on agricultural production	Provide the potential for enhanced agricultural production
Social	Minimise risk to human health and life	(i) residents	3.A.(i)	Annual Average Number of residential properties at risk from flooding	Number of properties at risk is not increased	100% reduction in number of residential properties at risk
		(ii) high vulnerability properties	3.A.(ii)	Number and type of high vulnerability properties at risk from flooding	Number of high vulnerability properties at risk not increased	100% reduction in number of high vulnerability properties at risk
	Minimise risk to community	(i) social infrastructure	3.B.(i)	Number of social infrastructure assets at risk from flooding in a 0.1% AEP Event	Number of social infrastructure assets at risk not increased	100% reduction in number of social infrastructure assets at risk
	"	(ii) local employment	3.B.(ii)	Number of non-residential (i.e., commercial) properties at risk not increased.	Number of non-residential properties at risk not increased	100% reduction in number of non-residential properties at risk
	Minimise risk to, and where possible enhance, social amenity sites	"	3.C	Number of social amenity sites at risk from flooding in a 1% AEP Event	Number of social amenity sites at risk not increased	100% reduction in number of flood-sensitive social amenity sites at risk. Enhancement or creation of social amenity sites
Environmental	Support the objectives of the WFD	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives	4.A	-	Provide no constraint to the achievement of water body objectives.	Contribute to the achievement of water body objectives
	Support the objectives of the Habitats and Birds Directives	Avoid detrimental effects to, and where possible enhance, Natura 200 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	4.B	-	No deterioration in the conservation status of designated sites as a result of flood risk management measures.	Improvement in the conservation status of designated sites as a result of flood risk management sites.
	Avoid damages to, and where possible enhance, the flora and fauna of the catchment	Avoid damage to, and where possible enhance, legally protected sites / habitats and other sites / habitats of national, regional and local nature conservation importance	4.C	-	No deterioration in the condition of existing sites due to the implementation of flood risk management option	Creation of new or improvement in condition of existing sites due to the implementation of flood risk management option
	Protect and where possible enhance fisheries resource within the catchment	Maintain existing and where possible create new fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species	4.D	-	No loss of integrity of fisheries habitat. Maintenance of upstream accessibility	No loss of fisheries habitat. Improvement in habitat quality/quantity. Enhanced upstream accessibility
	Protect and where possible enhance, landscape character and visual amenity within the zone of influence.	Protect, and where possible enhance, visual amenity, landscape protection zones and views into/from designated scenic areas within the zone of influence	4.E	-	No significant impact on landscape designation (protected site, scenic route/amenity, natural landscape form) within zone of visibility of measures. No significant change in the quality of existing landscape characteristics of the receiving environment	No change to the existing landscape form. Enhancement of existing landscape or landscape feature
	Avoid damage to or loss of features of cultural heritage importance and their setting, and improve their protection from extreme floods.	(i) Avoid damage to or loss of features of architectural value and their setting, and improve their protection from extreme floods where this is beneficial	4.F.(i)	-	No increase in the risk to architectural features at risk from flooding. No detrimental impacts from flood risk management measures on architectural features.	Complete removal of all relevant architectural features from the risk of harm by extreme floods. Enhanced protection and value of architectural features importance arising from the implementation of the selected measures.
	"	(ii) Avoid damage to or loss of features of archaeological value and their setting, and improve their protection from extreme floods where this is beneficial	4.F.(ii)	-	No increase in the risk to archaeological features at risk from flooding. No detrimental impacts from flood risk management measures on archaeological features.	Complete removal of all relevant archaeological features from the risk of harm by extreme floods. Enhanced protection and value of archaeological features importance arising from the implementation of the selected measures.

C2 MCA Scoring Sheets

Multicriteria Analysis - Flood Risk Management OPTION 1 - Flow Reduction in South Channel and Direct Defences

Core Criteria	Objective	Global Weighting	Local Weighting	Local Weighting Rationale	FRS OPTION 1 - Flow Reduction in South Channel and Direct Defences: SCORING	Rationale	MCA SCORE
Technical	Ensure flood risk management options are operationally robust	20	5	As per GN28 guidance	2	Low operational risk, as flood relief scheme relies on implementation of only one flow regulation structure at head of South Channel. Will include automation, redundancy and back up stop logs. Closing of insitu flood barriers/gates required on both north and south channel.	200
	Minimise health and safety risk in construction and operation of the flood risk management option	20	5	As per GN28 guidance	1	Moderate H&S risks during construction works, however risk is acceptable and manageable. There is work to be done in-channel with this option with construction of one flow regulation structure, resulting in some increase in risk. Construction required in the South Channel, however this is offset by no construction on Curragheen. Risks include deep excavations, working near water and services diversions during construction and maintenance stages. Limited operational risk related to operation of choke structure on south channel	100
	Ensure flood risk can be managed effectively and sustainably into the future	20	5	As per GN28 guidance	2	All proposed options will require the incorporation of elements of other options to adapt for climate change.	200
		60				**Technical Score**	**500**
Economic	Reduce economic damage	30	5	As per GN28 guidance	5	All options scored similar at close to top scores as each option provides protection to the same 1 in 100 year standard, with no significant difference in residual risk to the economy, transport or utility infrastructure	750
	Minimise risk to transport infrastructure	10	5	A number of key infrastructure routes are at risk.	5		250
	Minimise risk to utilities infrastructure	10	5	Considered to be an important area for utility services and assets.	4	Mark deducted for potential service interuptions during construction works.	200
	Minimise risk to agriculture	10	5	Set at 5 due to significance of potential agricultural loss upstream in catchment.	-5	The scheme includes creation of washlands by pre-emptive advance spilling of water from the reservoirs at higher rates. Therefore these lands will be subject to a greater frequency of lower or medium flooding events. The works will impact the use of these agricultural lands.	-250
		60				**Economic Score**	**950**
Social	Minimise risk to human health and life	30	5	All set at maximum local weighting due to significant existing risk, regular flood history and local feedback of both personal and business impacts of past flooding	5	Defence works provide protection to the 1% AEP fluvial and 0.5% tidal design standard.	750
		10	5		5		250
	Minimise risk to community	5	5		5		125
	"	10	5		5		250
	Minimise risk to, and where possible enhance, social amenity sites	5	5		5		125
		60				**Social Score**	**1500**
Environmental	Support the objectives of the WFD	15	5	As per GN28 guidance	0	Reduced flooding in area with no significant polluting sources. However there is potential for temporary impact during construction stage. Local Instream works at south channel flow control structure.	0
	Support the objectives of the Habitats and Birds Directives	15	3	Local weighting reflects absence of SACs and SPAs in close proximity to works area.	-1	Potential for construction related water-quality impacts on water dependent Annex I habitats and Annex II species as a result of instream works.	-45
	Avoid damages to, and where possible enhance, the flora and fauna of the catchment	5	3	Local weighting reflects absence of sensitive areas such as NHAs, national parks etc. in close proximity to works area.	-1	Potential for loss of hedgerow/woody vegetation during construction works with impacts on native bird species. Potential for loss of flora species on quay walls. Potential for disturbance and spread of invasive Japanese Knotweed and other non-native/invasive species during bankside construction works. This score was selected on the basis that the area impacted by this option is the smallest.	-15
	Protect and where possible enhance fisheries resource within the catchment	5	5	As per GN28 guidance	-2	Short-term minor impacts to fisheries habitat, construction phase impacts. Flow regulation structure at head of South Channel. Potential impact / loss of floating river vegetation. Potential for construction related water-quality impacts on fish species as a result of instream and bankside works. Potential for habitat loss for fish species. Potential for obstruction to migration of fish species. This option does not include Curragheen Reiver.	-50
	Protect and where possible enhance, landscape character and visual amenity within the zone of influence.	10	5	As the majority of this FRS is within Cork city, aesthetics and landscape character are considered to be significantly important.	-2	Potential impacts range from imperceptible to moderate landscape and visual impacts along both North and South Channels, with potential for some localised significant impacts along sections, particularly open spaces along the North Channel. This option excludes landscape and visual impacts of proposed flood defences in the Curragheen Area.	-100
	Avoid damage to or loss of features of cultural heritage importance and their setting, and improve their protection from extreme floods.	5	5	The City Development Plan lists over 1,000 buildings and features within the city area in the Record of Protected Structures and many of these are located within the streetscape in the environs of the river channels. Therefore this has been set at a high rating.	-1	Defence works will result in range of slight to moderate negative impacts on historic quays and associated features along both channels. Defence works will provide greater standard of flood protection to architectural heritage features within surrounding streetscape.	-25
	"	5	4		0	Option does not extend into the area of the medieval city and will not directly impact on any recorded archaeological monuments.	0
		60				**Environmental Score**	-235

MCA Benefit Score	**2215**
Option Selection Benefit Score	**2715**
Total Capital Costs (M€)	**90.00**
MCA Benefit/Cost Ratio	**0.025**

Core Criteria	Objective	Global Weighting	Local Weighting	Local Weighting Rationale	SCORING	Rationale	MCA SCORE
Multicriteria Analysis - Flood Risk Management OPTION 2 - Isolation of South Channel and Direct Defences					**FRS OPTION 2 - Isolation of South Channel and Direct Defences**		
Technical	Ensure flood risk management options are operationally robust	20	5	As per GN28 guidance	-1	Moderate/high operational risk, as flood relief scheme relies on implementation of four inter-related flow regulation structures on the South Channel and Curragheen. Timing of closing of structures is important, resulting in a complex operational scheme. Closing of insitu flood barriers/gates required on north channel.	-100
	Minimise health and safety risk in construction and operation of the flood risk management option	20	5	As per GN28 guidance	0	Moderate H&S risks during construction works and operation, however risk is acceptable and manageable. There is more substantial work to be done in-channel with this option with construction of four flow regulation structures, resulting in greater risk. There is less construction required in the South Channel, however this is offset by more construction in Curragheen. Risks include deep excavations, working near water and services diversions during construction and maintenance stages.A large number of operational activities required during implementation	0
	Ensure flood risk can be managed effectively and sustainably into the future	20	5	As per GN28 guidance	2	All proposed options will require the incorporation of elements of other options to adapt for climate change.	200
		60				**Technical Score**	**100**
Economic	Reduce economic damage	30	5	As per GN28 guidance	5	All options scored similar at close to top scores as each option provides protection to the same 1 in 100 year standard, with no significant difference in residual risk to the economy, transport or utility infrastructure	750
	Minimise risk to transport infrastructure	10	5	A number of key infrastructure routes are at risk.	5		250
	Minimise risk to utilities infrastructure	10	5	Considered to be an important area for utility services and assets.	4	No service interuptions in South Channel area, however this is balanced by potential issues in Curragheen area.	200
	Minimise risk to agriculture	10	5	Set at 5 due to significance of potential agricultural loss upstream in catchment.	-5	The scheme includes creation of washlands by pre-emptive advance spilling of water from the reservoirs at higher rates. Therefore these lands will be subject to a greater frequency of lower or medium flooding events. The works will impact the use of these agricultural lands.	-250
		60				**Economic Score**	**950**
Social	Minimise risk to human health and life	30	5	All set at maximum local weighting due to significant existing risk, regular flood history and local feedback of both personal and business impacts of past flooding	5	Defence works provide protection to the 1% AEP fluvial and 0.5% tidal design standard.	750
		10	5		5		250
	Minimise risk to community	5	5		5		125
	"	10	5		5		250
	Minimise risk to, and where possible enhance, social amenity sites	5	5		5		125
		60				**Social Score**	**1500**
Environmental	Support the objectives of the WFD	15	5	As per GN28 guidance	-4	Reduced flooding in area with no significant polluting sources. However scheme includes a tidal barrage, flow diversion during flood events and works on Curragheen.	-300
	Support the objectives of the Habitats and Birds Directives	15	3	Local weighting reflects absence of SACs and SPAs in close proximity to works area.	-3	Potential for construction related water-quality impacts on water dependent Annex I habitats and Annex II species as a result of instream works. This option has greatest instream works	-135
	Avoid damages to, and where possible enhance, the flora and fauna of the catchment	5	3	Local weighting reflects absence of sensitive areas such as NHAs, national parks etc. in close proximity to works area.	-2	Potential for loss of hedgerow/woody vegetation during construction works with impacts on native bird species. Potential for loss of flora species on quay walls. Potential for disturbance and spread of invasive Japanese Knotweed and other non-native/invasive species during bankside construction works. This score was selected on the basis that the area impacted by this option includes the Curragheen.	-30
	Protect and where possible enhance fisheries resource within the catchment	5	5	As per GN28 guidance	-4	Medium impact to fisheries habitat. Flow diversion of Curragheen and Glasheen during flood events. Potential impact / loss of floating river vegetation. Tidal barrage at South Channel mouth. Works on natural banks on Curragheen River. Potential for construction related water-quality impacts on fish species as a result of instream and bankside works. Potential for habitat loss for fish species. Potential for obstruction to migration of fish species.	-100
	Protect and where possible enhance, landscape character and visual amenity within the zone of influence.	10	5	As the majorty of this FRS is within Cork city, aesthetics and landscape character are considered to be significantly important.	-4	Potential impacts range from imperceptible to moderate landscape and visual impacts along the North Channel, with potential for localised significant impacts along sections, particularly open spaces along of the North Channel. Proposed walls greater than 2m would result in moderate to locally significant landscape and visual impacts in sections of the Curragheen area. This option removes landscape and visual impacts along the South Channel and quays, apart from the flow control structure near Custom House.	-200
	Avoid damage to or loss of features of cultural heritage importance and their setting, and improve their protection from extreme floods.	5	5	The City Development Plan lists over 1,000 buildings and features within the city area in the Record of Protected Structures and many of these are located within the streetscape in the environs of the river channels. Therefore this has been set at a high rating.	-2	Defence works will result in range of slight to moderate negative impacts on historic quays and associated features along north channel. Option will reduce negative impacts on the South Channel historic quays and associated features. However, in this option, Custom House will be impacted aesthetically with the location of the flow isolation structure (tidal barrage) on the South Channel. Defence works will provide greater standard of flood protection to architectural heritage features within surrounding streetscape.	-50
	"	5	4		0	Option does not extend into the area of the medieval city and will not directly impact on any recorded archaeological monuments.	0
		60				**Environmental Score**	**-815**

MCA Benefit Score	**1635**
Option Selection Benefit Score	**1735**
Total Capital Costs (M€)	**84.00**
MCA Benefit/Cost Ratio	**0.019**

Multicriteria Analysis - Flood Risk Management OPTION 3 - Direct Defences Only							
					FRS OPTION 3 - Direct Defences Only		
Core Criteria	**Objective**	**Global Weighting**	**Local Weighting**	**Local Weighting Rationale**	**SCORING**	**Rationale**	**MCA SCORE**
Technical	Ensure flood risk management options are operationally robust	20	5	As per GN28 guidance	3	Very low operational risk. Direct defences only so little intervention during a flood event, with exception of closing of flood barriers/gates on both channels.	300
	Minimise health and safety risk in construction and operation of the flood risk management option	20	5	As per GN28 guidance	2	Moderate H&S risks during construction works, however risk is acceptable and manageable. Construction required in both the South Channel and the Curragheen. Risks include deep excavations, working near water and services diversions during construction and maintenance stages.	200
	Ensure flood risk can be managed effectively and sustainably into the future	20	5	As per GN28 guidance	2	All proposed options will require the incorporation of elements of other options to adapt for climate change.	200
		60				**Technical Score**	**700**
Economic	Reduce economic damage	30	5	As per GN28 guidance	5	All options scored similar at close to top scores as each option provides protection to the same 1 in 100 year standard, with no significant difference in residual risk to the economy, transport or utility infrastructure	750
	Minimise risk to transport infrastructure	10	5	A number of key infrastructure routes are at risk.	5		250
	Minimise risk to utilities infrastructure	10	5	Considered to be an important area for utility services and assets.	3	The construction works required in this option covers the greatest area, therefore it is likely that there will be more potential service interuptions during construction works.	150
	Minimise risk to agriculture	10	5	Set at 5 due to significance of potential agricultural loss upstream in catchment.	-5	The scheme includes creation of washlands by pre-emptive advance spilling of water from the reservoirs at higher rates. Therefore these lands will be subject to a greater frequency of lower or medium flooding events. The works will impact the use of these agricultural lands.	-250
		60				**Economic Score**	**900**
Social	Minimise risk to human health and life	30	5	All set at maximum local weighting due to significant existing risk, regular flood history and local feedback of both personal and business impacts of past flooding	5	Defence works provide protection to the 1% AEP fluvial and 0.5% tidal design standard.	750
		10	5		5		250
	Minimise risk to community	5	5		5		125
	"	10	5		5		250
	Minimise risk to, and where possible enhance, social amenity sites	5	5		5		125
		60				**Social Score**	**1500**
Environmental	Support the objectives of the WFD	15	5	As per GN28 guidance	-2	Reduced flooding in area with no significant polluting sources. However scheme includes additional works on Curragheen.	-150
	Support the objectives of the Habitats and Birds Directives	15	3	Local weighting reflects absence of SACs and SPAs in close proximity to works area.	-1	Potential for construction related water-quality impacts on water dependent Annex I habitats and Annex II species as a result of instream works.	-45
	Avoid damages to, and where possible enhance, the flora and fauna of the catchment	5	3	Local weighting reflects absence of sensitive areas such as NHAs, national parks etc. in close proximity to works area.	-3	Potential for loss of hedgerow/woody vegetation during construction works with impacts on native bird species. Potential for loss of flora species on quay walls. Potential for disturbance and spread of invasive Japanese Knotweed and other non-native/invasive species during bankside construction works. This score was selected on the basis that the area impacted by this option is the greatest.	-45
	Protect and where possible enhance fisheries resource within the catchment	5	5	As per GN28 guidance	-1	Medium impact to fisheries habitat. Works on natural banks on Curragheen River. Potential for construction related water-quality impacts on fish species as a result of instream and bankside works. Potential for habitat loss for fish species. Potential for obstruction to migration of fish species.	-25
	Protect and where possible enhance, landscape character and visual amenity within the zone of influence.	10	5	As the majorty of this FRS is within Cork city, aesthetics and landscape character are considered to be significantly important.	-3	Potential impacts range from imperceptible to moderate landscape and visual impacts along both the North and South Channels, and the Curragheen area, with potential for localised significant impacts along sections, particularly open spaces along the North Channel, as well as the Curragheen river area, where flood defence walls are proposed but slightly lower than in Option 2. There is also potential for visual and landscape impact due to increased flood defences along the South Channel.	-150
	Avoid damage to or loss of features of cultural heritage importance and their setting, and improve their protection from extreme floods.	5	5	The City Development Plan lists over 1,000 buildings and features within the city area in the Record of Protected Structures and many of these are located within the streetscape in the environs of the river channels. Therefore this has been set at a high rating.	-1	Defence works will result in range of slight to moderate negative impacts on historic quays and associated features along both channels. Defence works will provide greater standard of flood protection to architectural heritage features within surrounding streetscape.	-25
	"	5	4		0	Option does not extend into the area of the medieval city and will not directly impact on any recorded archaeological monuments.	0
		60				**Environmental Score**	**-440**

MCA Benefit Score	**1960**
Option Selection Benefit Score	**2660**
Total Capital Costs (M€)	**98.00**
MCA Benefit/Cost Ratio	**0.020**

C3 MCA Scoring Summary

Multicriteria Analysis Summary Sheet				
Lower Lee (Cork City) Drainage Scheme	**FRS OPTION 0 - 'Do Minimum'**	**FRS OPTION 1 - Flow Reduction in South Channel and Direct Defences**	**FRS OPTION 2 - Isolation of South Channel and Direct Defences**	**FRS OPTION 3 - Direct Defences Only**
Technical Score	-200100	500	100	700
Economic Score	-249800	730	950	900
Social Score	-299700	1500	1500	1500
Environmental Score	0	-235	-815	-440
MCA Benefit Score	-549500	2215	1635	1960
Option Selection Benefit Scor	-749600	2715	1735	2660
Total Capital Costs (M€)	0.5	90	84	98
MCA Benefit/Cost Ratio	-1099	0.0246	0.0195	0.0200