



Kilkenny County Council
Comhairle Chontae Chill Chainnigh

In association with _____



OPW
Oifig na nOibreacha Poiblí
Office of Public Works



Tionscadal Éireann
Project Ireland
2040

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Graiguenamanagh-Tinnahinch Flood Relief Scheme



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The purpose of this document is to describe the options being considered by the project team and the relative benefits and constraints of each option.

Introduction

To assess and develop a suitable flood relief scheme for Graiguenamanagh-Tinnahinch, a long list of measures has been initially considered. The purpose of this was to establish which measures would be effective for the Graiguenamanagh-Tinnahinch area and those which would be unsuitable.

Measures can be combined to form Options, which taken together, provide a level of protection against flooding.

DESIGN STANDARD

The design Standard of Protection (SoP) sought for the Graiguenamanagh-Tinnahinch Flood Relief Scheme (GTFRS) is the 1% annual equivalent probability (AEP) event. This can be thought of as a flood with a magnitude such that it has a 1% chance of occurring in any given year and is sometimes referred to as the 100 year flood.

The scheme will also be assessed for resistance/adaption to climate change and greater than design flood events.

LIST OF MEASURES CONSIDERED

As part of the GTFRS, a long list of measures was initially considered. The purpose of this screening exercise was to establish which measures would be effective for Graiguenamanagh-Tinnahinch as well as those that would be suitable.

A summary of the outcome is provided in the table below. Viable measures were then further assessed to determine their effectiveness and ultimately combined with other measures to form Options.

INITIAL OPTIONS

Following on from the initial screening, a list of viable options which were likely to be successful in achieving the Scheme Standard of Protection (SoP) was developed.

Only one option was found to be technically, socially, environmentally and economically viable for flood risk arising from the River Barrow. The Options therefore focus on measures of flood risk reduction on the River Duiske.

The preferred scheme will be selected based on a balance between the technical, economic, cultural heritage, social and environmental aspects of each option.

The relative benefits and constraints associated with the Options are discussed later in this document. The options developed are:

Option No. 1	Raised Defences
Option No. 2	Raised Defences & River Duiske Flow Diversion
Option No. 3	Raised Defences & River Duiske Storage
Option No. 4	Raised Defences & River Duiske Storage and Diversion
Option No. 5	Raised Defences & River Duiske Culvert

No.	Measures	Outcome of Initial Assessment
1	Do nothing	Baseline measure only for comparison.
2	Non-structural measures	
2a	Flood warning	Potential on the Barrow but not on the Duiske due to lack of advanced warning time.
2b	Individual property protection	Potential, but not preferred due to increased risk of failure by having more components in the flood protection measure.
2c	Development management	Continue to implement under the Kilkenny/Carlow County Council Development Plans.
3	Properties or infrastructure relocation	Not considered socially acceptable on a large scale. Potential on a localised//individual scale.
4	Properties or infrastructure reconstruction to a higher level	Not viable in town centre setting such as for Graiguenamanagh & Tinnahinch.
5	Flow diversion	
5a	Diversion of entire river	Not viable given the environmental sensitivity and protections afforded to the River Barrow and the River Duiske.
5b	Flood flow bypass channel	Not viable on the River Barrow given the environmental sensitivity and protections afforded to River Barrow, particularly given the scale required. Potential on the River Duiske, provide adequate base flows can be maintain in original channel.
6	Flow reduction	
6a	Upstream catchment management	Not viable to achieve the scheme SOP.
6b	Upstream flood storage	Not viable to achieve the Scheme SOP on the River Barrow or Duiske, but potential to reduce flows on River Duiske is considerable.
7	Flood containment	
7a	Walls or Embankments (Hard Defences)	Viable to contain the flow within the channel but increases flood levels when used as the only measure.
7b	Demountable defences	Will be required at some locations, but preference is to limit use as much as possible.
8	Increased conveyance	
8a	Channel upgrade (channel or floodplain section and/or grade)	Not preferable given the environmental sensitivity and protections afforded to the River Barrow and the River Duiske.
8b	Channel maintenance (channel or floodplain roughness improve)	Not viable to achieve the scheme SOP.
8c	Removal of local constraints	Not viable to achieve the scheme SOP, but considered in combination with other measures as part of ongoing maintenance.
9	Sediment management	Not viable to achieve the scheme SOP.
10	Storm water pumping behind defences	Typically required as part of any scheme.

Environmental - Cultural Heritage & Archaeology

Given that Graiguenamanagh town is an Architectural Conservation Area (ACA), encompassing the medieval core of the town, the Turf Market, the bridge and the historic quay, cultural heritage and archaeological considerations must be included in the development of the scheme. The Duiske Abbey is listed as a National Monument and subsequently is under a preservation order. It can be seen in Figure 11 and Figure 2 below, which also show other key cultural heritage and archaeological considerations.



Figure 1 Panoramic view of the Quay taken from the southern banks of the barrow east of Graiguenamanagh Bridge



Figure 2 Panoramic view of Tinnahinch from the western side of Graiguenamanagh Bridge

There are a significant amount of industrial heritage features recorded in the Record of Monuments and Places (RMP) and Record of Protected Structures (RPS) in the study area. These are largely associated with a legacy of milling and transport. There are thirty-five protected structures listed in the RPS in the study area boundary as seen in Figure 3. The properties recorded in the study area by the National Inventory of Architectural Heritage (NIAH, as seen in Figure 4) are considered as being buildings and structures of conspicuous historical, archaeological, artistic, scientific, social or technical interest and are recorded by this survey as having a ‘Regional’ rating. Structures that are considered of regional significance are recommended by the Minister to the relevant planning authority for inclusion in their RPS. Additionally, survey work carried out in preparation for this scheme found items of archaeological significance underwater. Figure 5 below shows the location of these finds. These designations have been considered through the development of the GTFRS options listed in subsequent pages.

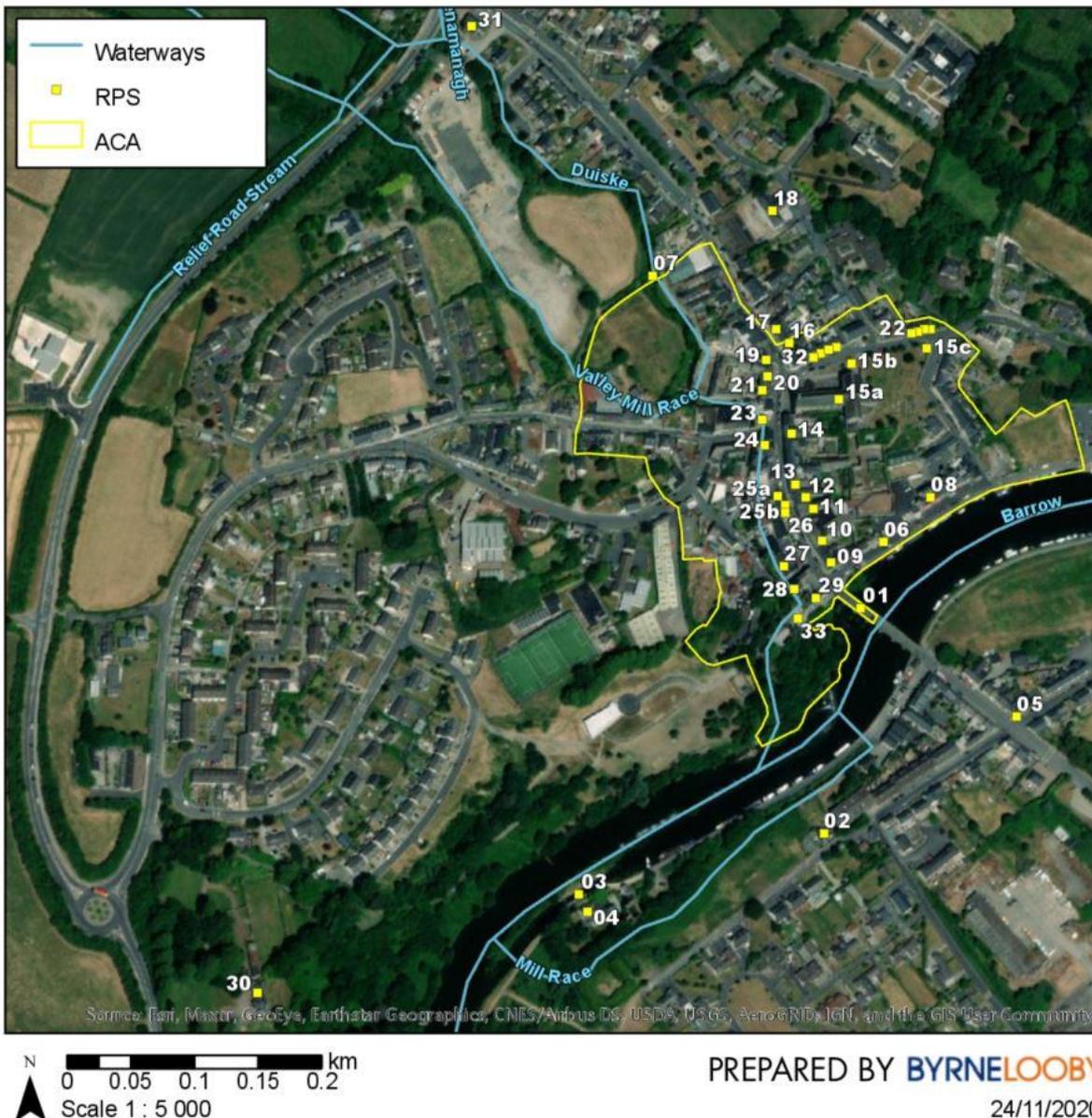


Figure 3 Record of Protected Structures in the proposed scheme area

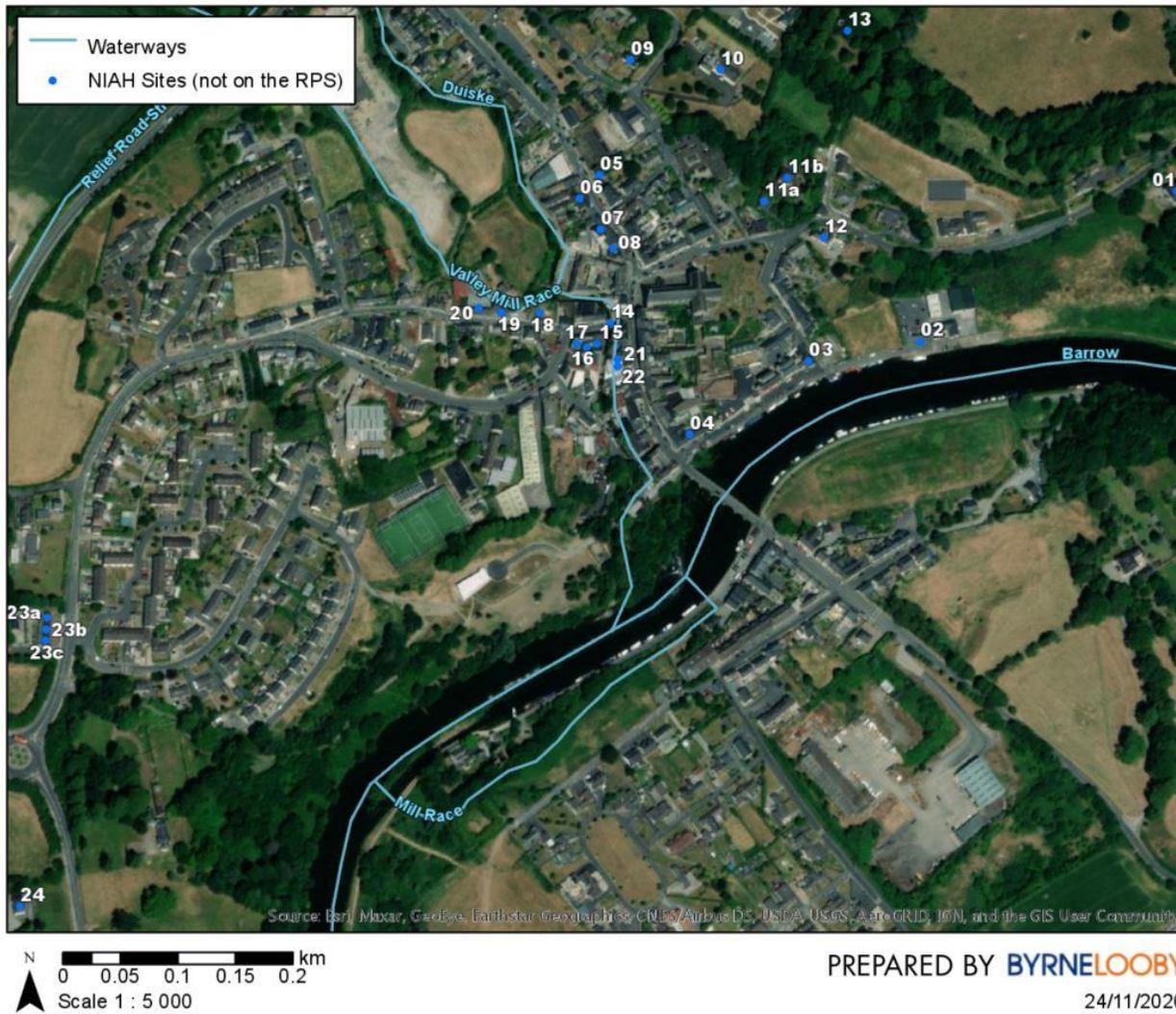


Figure 4 National Inventory of Architectural Heritage in the proposed scheme area

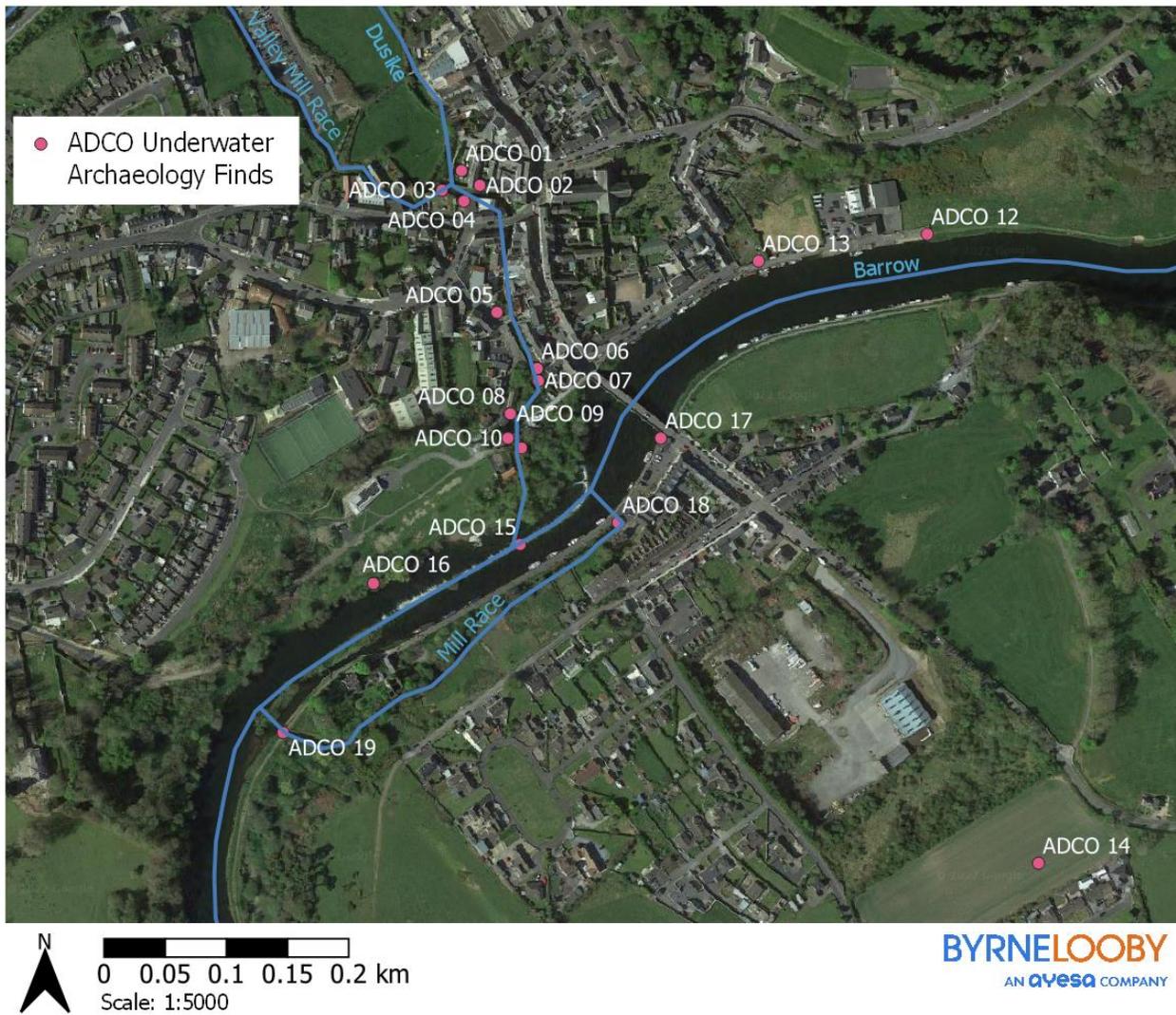


Figure 5 Additional Items of Interest noted by ADCO

Environmental - Biodiversity

The most significant ecological constraints at Graiguenamanagh are the River Barrow and the River Duiske given their status as a Special Area of Conservation (SAC). Figure 6 shows this SAC in relation to the proposed scheme area. Once an option has been chosen for the GTFRS, an Appropriate Assessment and Natura Impact Statement will be complete in accordance with Irish legislation to determine the extent of the impact of the proposed scheme on the River Barrow and River Nore SAC pending decision on the emerging preferred option. This will recommend ways to minimise and mitigate any impact. A full Constraints Study has been undertaken to identify all constraints relative to the scheme. The NIS will include recommendations to minimise and mitigate any potential impacts and ideally result in a new positive contribution to biodiversity.

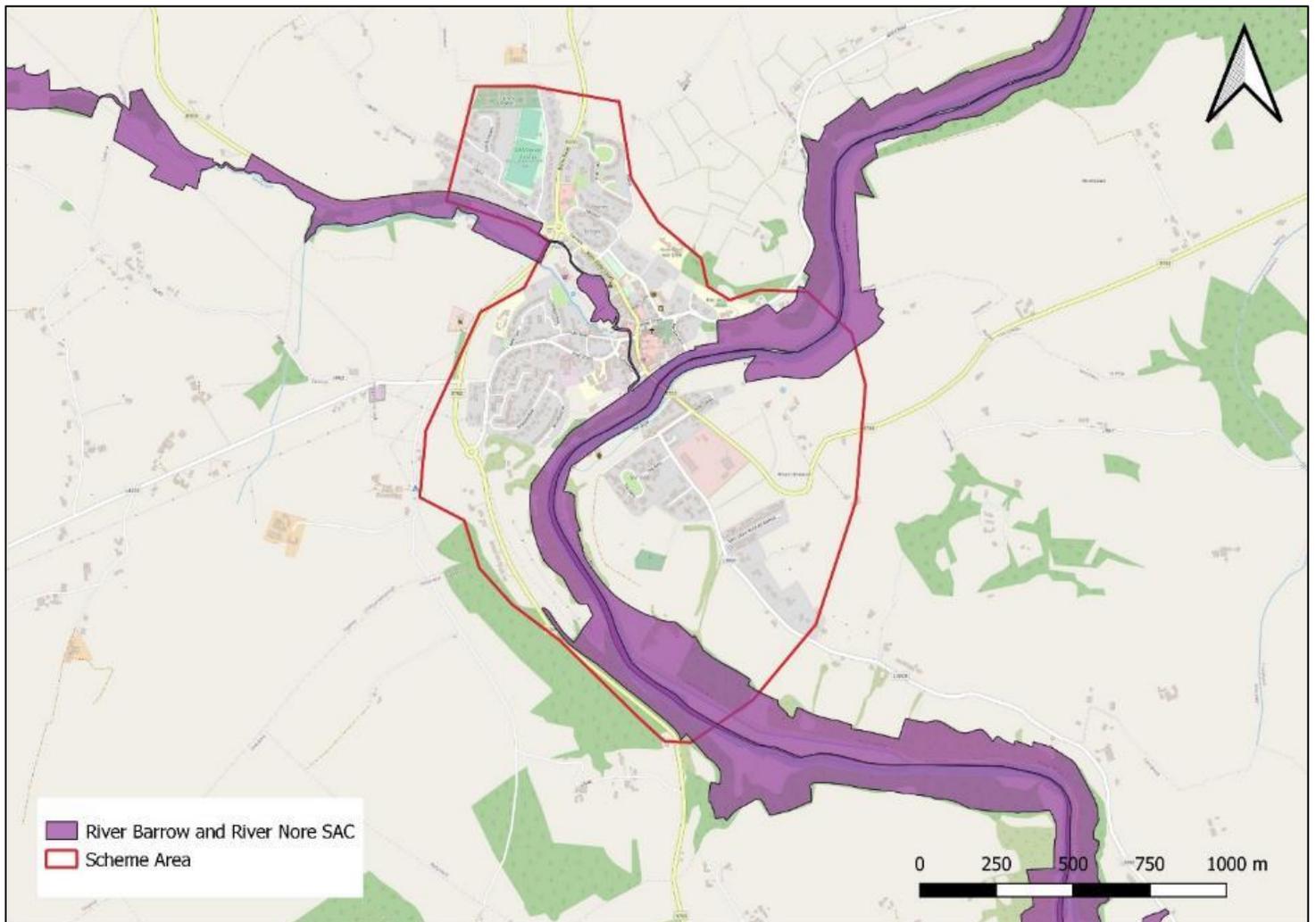


Figure 6 River Barrow and River Nore SAC

The river corridors (including the rivers themselves) potentially support numerous protected species including two species of lamprey, salmon, sea and brown trout, otter, bats, badger, and potentially red squirrel, pine marten, white-clawed crayfish and the common frog. However, surveys carried out showed no signs of otter, badger, red squirrel nor pine marten in the proposed scheme areas.

Table 1 outlines the habitats encountered in the scheme area which are mapped out in Figure 7 (overleaf). The distribution of habitats, as outlined below, has been considered as much as possible in the development of the proposed options to reduce impact. The full impact of the options will be assessed as part of an Appropriate Assessment and Environmental Impacts Assessment following the selection of the preferred option.

Table 1 Habitat Mapping Codes

Habitat Name	Habitat Code (as per Fossitt, 2000)
Eroding/Depositing Rivers	FW1/FW2
Canals	FW3
Reed and Large Sedge Swamp	FS1
Improved Agricultural Grassland	GA1
Amenity Grassland	GA2
Dry Meadows and Grassy Verges	GS2
Wet Grassland	GS4
Oak-birch-holly Woodland	WN1
Riparian Woodland	WN5
Wet Willow-alder-ash Woodland	WN6
Mixed Broadleaved Woodland	WD1
Scattered Trees and Parkland	WD5
Scrub	WS1
Ornamental/Non-native Scrub	WS3
Hedgerows/Treelines	WL1/WL2
Spoil and Bare Ground / Recolonising Bare Ground	ED2/ED3
Arable Crops	BC1
Stone Walls and Other Stonework	BL1
Earth Banks	BL2
Buildings and Artificial Surfaces	BL3

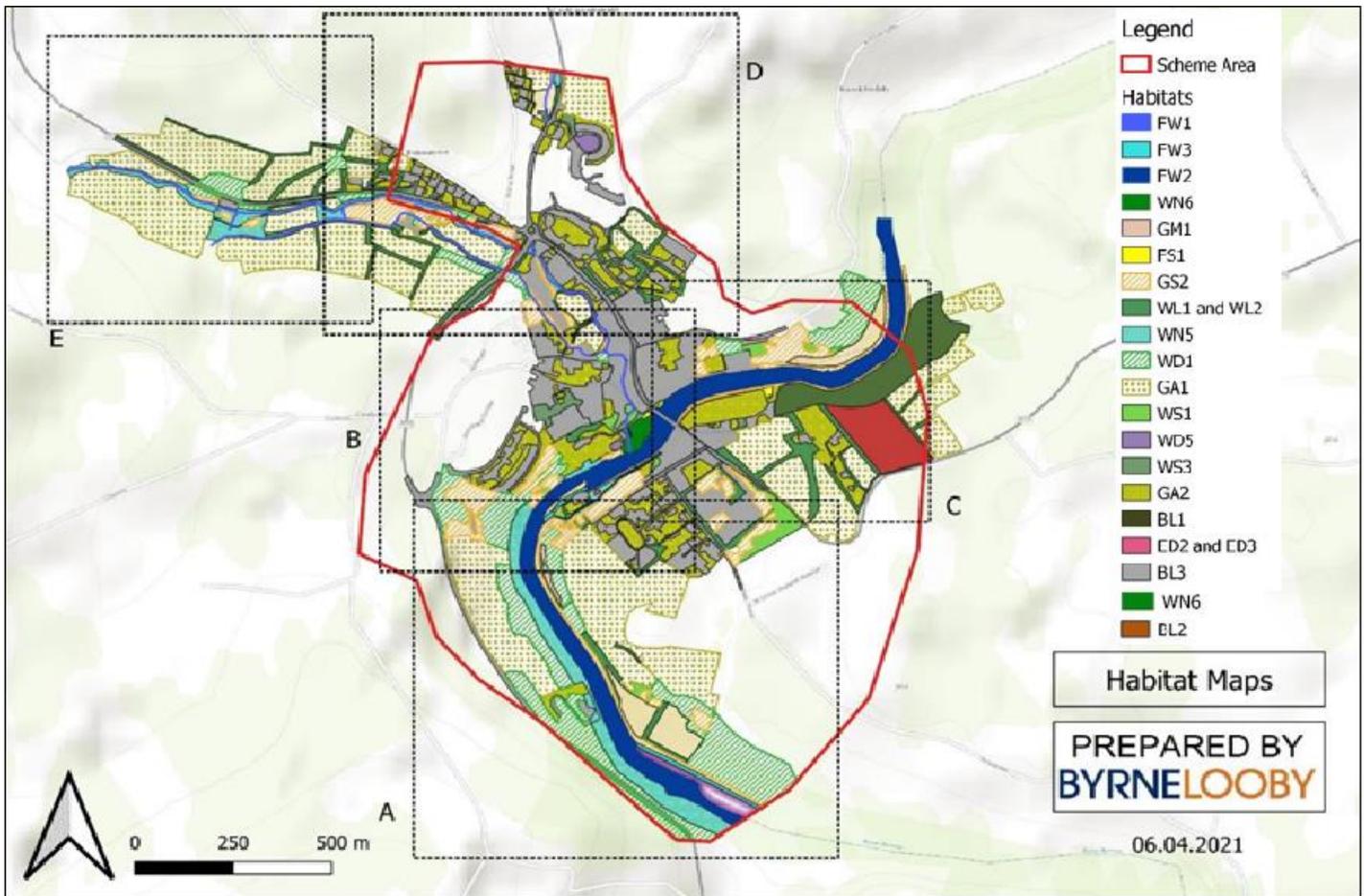


Figure 7 Habitat Mapping in proposed scheme area

Option 1 – Raised Defences

Description

Flood Defence embankments and walls form the defences on the River Barrow as shown in Figure 8. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access for water activities. Additionally, some local land raising areas are required to maintain access to properties. Back of wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

Flood defence walls are required on both banks of the River Duiske but primarily on the eastern side. Wall improvement to existing structures/walls is required upstream of High Street Bridge, as well as a replacement pedestrian access bridge and some local land raising. A debris trap is located upstream of the main at risk area adjacent to Well Lane.

At Turf Market, walls are required on the eastern bank at two locations as shown in Figure 8. Replacement bridges are required at these locations also to prevent flooding over the existing bridges.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defence heights and lengths. More precise wall heights for specific areas can be found on the drawings contained in the display posters.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 2.3m	271m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Wall Improvements on Right Bank	0.2 – 2.3m	16m
Bridge Replacements	3no.	<10m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

Benefits	Constraints
<p>Properties previously flooded are protected.</p> <p>A key transport route from Carlow to Kilkenny is protected.</p> <p>The option is economically viable.</p> <p>Hard defence walls typically replace existing walls or man-made banks where possible.</p> <p>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</p> <p>Almost no loss of biodiversity excepting some minor felling of trees at Turf Market etc. with this option.</p> <p>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</p> <p>Defences do not impose an overbearing solution on any particular property/landowner or group.</p>	<p>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</p> <p>Space for construction of defences on the left bank of the River Duiske at Turf Market is extremely limited. The technical complexity design and construction of defences is significant.</p> <p>Defences are required within the SAC, particularly on the River Duiske.</p> <p>Mitigation of temporary in-stream construction impacts on the SAC's Qualifying Interests is needed.</p> <p>There is a recognised preference among some members of the public to avoid raised defences in public areas such as Graiguenamanagh Quay.</p> <p>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</p> <p>Many properties have drains to the River Duiske which require non-return valves to prevent backflows to the properties.</p>

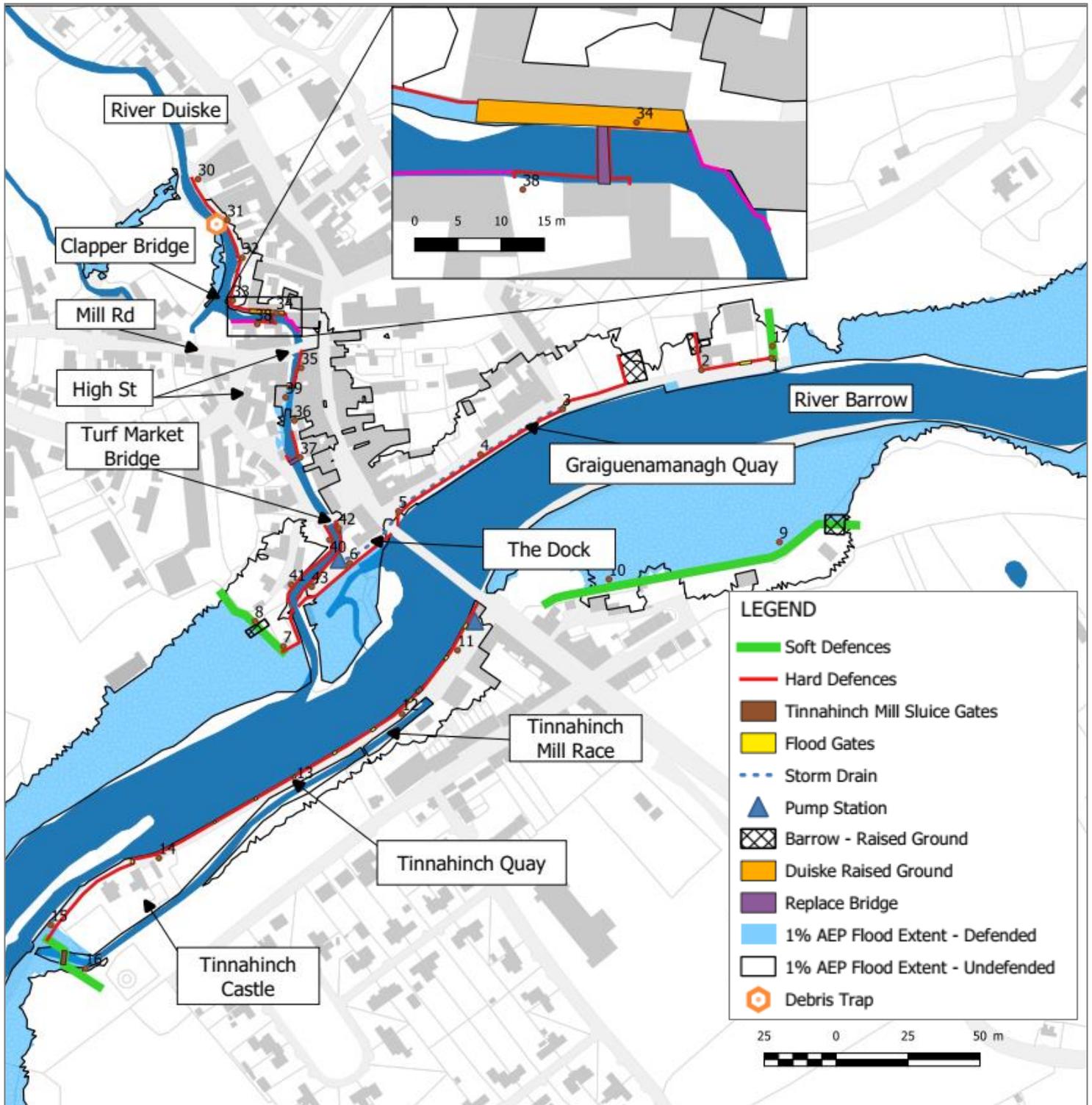


Figure 1: Option 1

Option 2 – Raised Defences & River Duiske Diversion

Description

Flood Defence embankments and walls form the defences on the River Barrow as shown in Figure 9. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access for water activities. Additionally, some local land raising areas are required to maintain access to properties. Back of wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

Flood defence walls are required on only one bank of the River Duiske at Well Lane, extending down to Clapper Bridge. At Clapper Bridge, diverted flows will be conveyed by means of a 1800mm diameter culvert to The Hub where an open channel will convey flows to the River Barrow. An instream weir/structure will be required to regulate flows into the culvert. A debris trap is located adjacent to Well Lane.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defence heights and lengths. More precise wall heights for specific areas can be found on the drawings contained in the display posters.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 1.0m	182m
Flood Walls on Right Bank	0.7 – 2.3m	106m
Diversion Weir	-	<10m
Flow Diversion - Culvert	-	219m
Flow Diversion – Open Channel	-	94m
Pedestrian/Vehicular Bridge	1no.	<10m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

Benefits	Constraints
<p>Properties that previously flooded are protected.</p> <p>A key transport route from Carlow to Kilkenny is protected.</p> <p>The Option is economically viable.</p> <p>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</p> <p>Hard defence walls typically replace existing walls where possible.</p> <p>Almost no loss of biodiversity, with this option.</p> <p>Tree felling limited to lower reaches of the Duiske and some other small pockets</p> <p>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</p> <p>Defences do not impose overbearing solutions on any particular property/landowner.</p> <p>Works at Turf Market are avoided.</p>	<p>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</p> <p>The defences do not protect the camping park at The Hub</p> <p>Defences are required within the SAC, particularly on the River Duiske. Consultation with NPWS is needed.</p> <p>Mitigation of temporary in-stream construction impacts on SAC's Qualifying Interests is needed.</p> <p>There is a recognised preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</p> <p>A flow control structure is required near Clapper Bridge, which impacts on archaeology and ecology.</p> <p>Deep excavations for the flow diversion culvert may necessitate diversion/ interference of the existing services.</p> <p>Long-duration road closures required at High St., Tinnahinch Quay, Graiguenamanagh Quay and The Dock.</p>

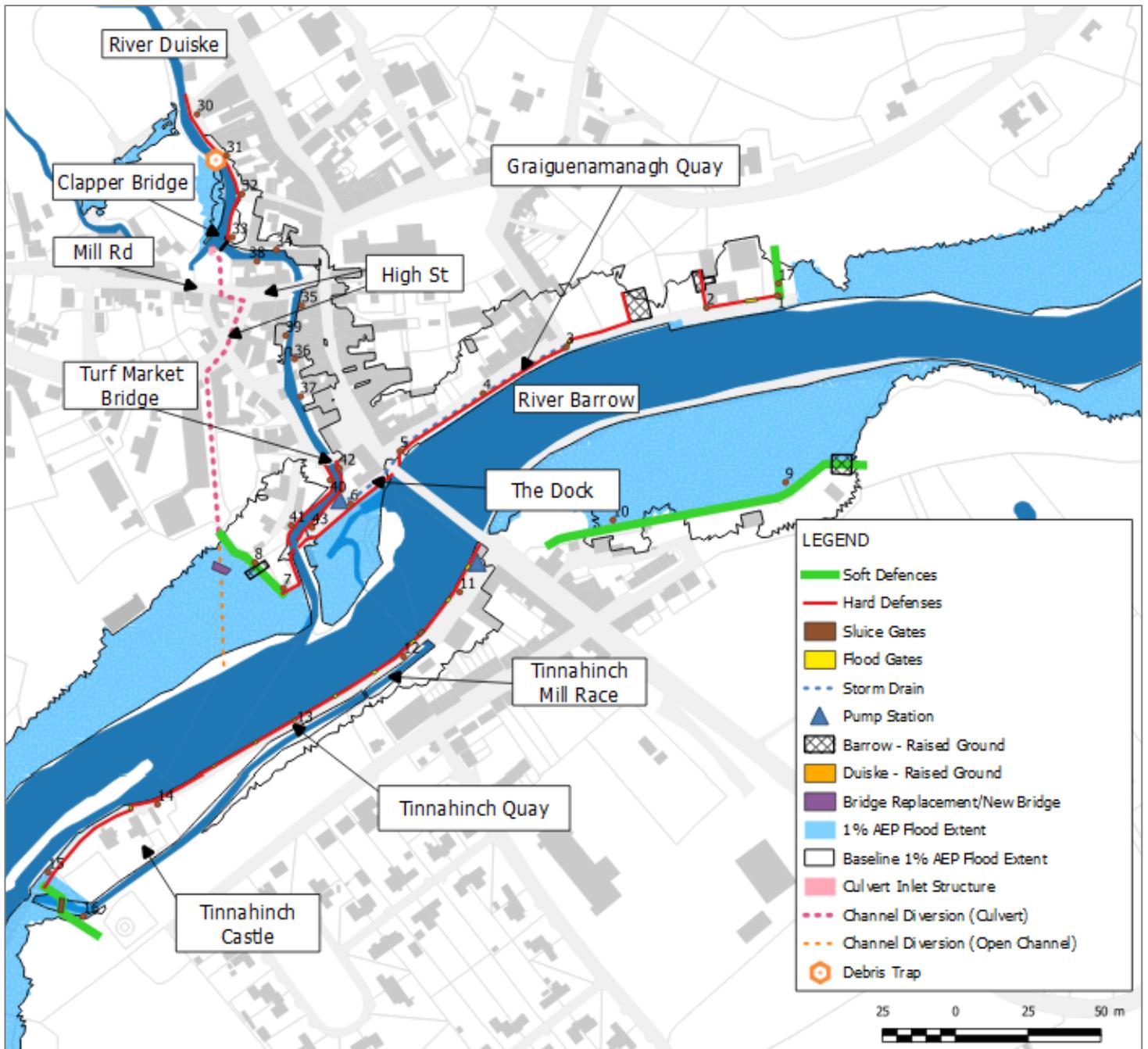


Figure 2: Option 2

Option 3 – Raised Defences & River Duiske Storage

Description

Flood Defence embankments and walls form the defences on the River Barrow as shown in Figure 10. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access for water activities. Additionally, some local land raising areas are required to maintain access to properties. Back of wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

Flood defence walls are required on only one bank of the River Duiske from Clapper Bridge downstream to the Turf Market area. A bridge replacement is also required at Turf Market, immediately downstream of High St. Bridge to maintain property access. Wall improvements are also required upstream of High St. Bridge. A debris trap is located adjacent to Well Lane.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Upstream of Graiguenamanagh an area is provided for storage. To create the storage area, an embankment must be built across the River Duiske that ties into high ground with a flow control structure to control the flow in the event of a flood.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option requires approximately the following defence heights and lengths. More precise wall heights for specific areas can be found on the drawings contained in the display posters.

<u>River Barrow</u>	<u>Heights</u>	<u>Length</u>
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
<u>River Duiske</u>		
Flood Walls on Left Bank	0.2 – 2.3m	138m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Bridge Replacement	1no.	<5m
Storage Embankment	1.0 - 7.0m	152m
<u>River Barrow</u>	<u>Heights</u>	<u>Length</u>
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

Benefits	Constraints
<p>Properties that previously flooded are protected.</p> <p>A key transport route from Carlow to Kilkenny is protected.</p> <p>The option is economically viable.</p> <p>The option avoids all instream works in the River Barrow.</p> <p>Hard defence walls typically replace existing walls where possible.</p> <p>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</p>	<p>The number of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</p> <p>Defences are required within the SAC, particular on the River Duiske.</p> <p>Mitigation of temporary in-stream construction impacts on SAC QIs will likely be needed.</p> <p>There is a known preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</p> <p>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures will require a warning and deployment plan.</p> <p>Many properties have drains to the River Duiske which will need to have non-return valves fitted to prevent backflows to the properties.</p> <p>Requires a large amount of land acquisition for storage area.</p> <p>Permanent in-stream works required in the River Duiske have the potential to impact Water Framework Directive objectives.</p> <p>Changes to habitats at location of storage area</p>

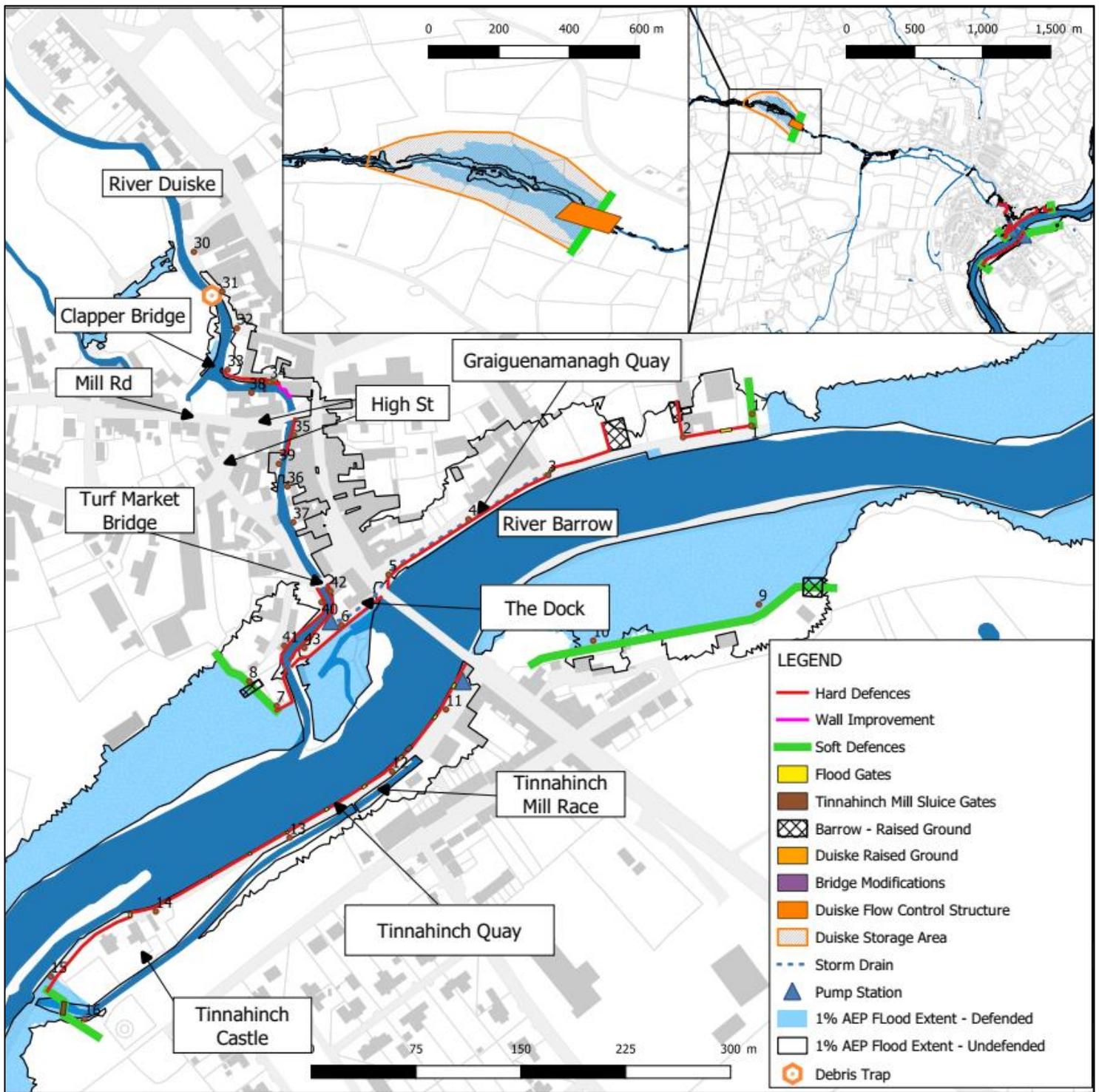


Figure 3: Option 3

Option 4 – Raised Defences & River Duiske Storage and Diversion

Description

Flood Defence embankments and walls form the defences on the River Barrow as shown in Figure 11. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access for water activities. Additionally, some local land raising areas are required to maintain access to properties. Back of wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

On the River Duiske, walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates. No walls are required upstream of Turf Market Bridge.

Upstream of Graiguenamanagh an area is provided for storage. To create the storage area, an embankment must be built across the River Duiske that ties into high ground with a flow control structure to control the flow in the event of a flood.

At Clapper Bridge, diverted flows will be conveyed by means of a 1800mm diameter culvert to The Hub where an open channel will convey flows to the River Barrow. An instream weir/structure will be required to regulate flows into the culvert. A debris trap is located adjacent to Well Lane.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defence heights and lengths. More precise wall heights for specific areas can be found on the drawings contained in the display posters.

<u>River Barrow</u>	<u>Heights</u>	<u>Length</u>
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
<u>River Duiske</u>		
Flood Walls on Left Bank	0.2 – 1.0m	68m
Flood Walls on Right Bank	0.7 – 2.3m	106m
Diversion Weir	-	<10m
Flow Diversion – Culvert	-	219m
Flow Diversion – Open Channel	-	94m
Pedestrian Bridge	1no.	<10m
Storage Embankment	1.0 - 7.0m	152m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

Benefits	Constraints
<p>Properties that previously flooded are protected.</p> <p>A key transport route from Carlow to Kilkenny is protected.</p> <p>The option is economically viable.</p> <p>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</p> <p>Hard defence walls are largely avoided on the Duiske, except below Turf Market Bridge.</p> <p>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</p> <p>Reduced lengths and heights of defences required on the Duiske..</p>	<p>The density of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</p> <p>Defences are required within the SAC, particular on the River Duiske.</p> <p>There is a recognised preference among some members of the public to avoid hard defences in public areas such as Graiguenamanagh Quay.</p> <p>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</p> <p>Requires a large amount of land acquisition for the storage area.</p> <p>In-stream works are required in the River Duiske. Mitigation of temporary in-stream construction impacts on SAC's Qualifying Interests will likely be needed.</p> <p>Permanent in-stream works required in the River Duiske have the potential to impact Water Framework Directive objectives.</p> <p>Changes to habitats at location of storage area.</p>

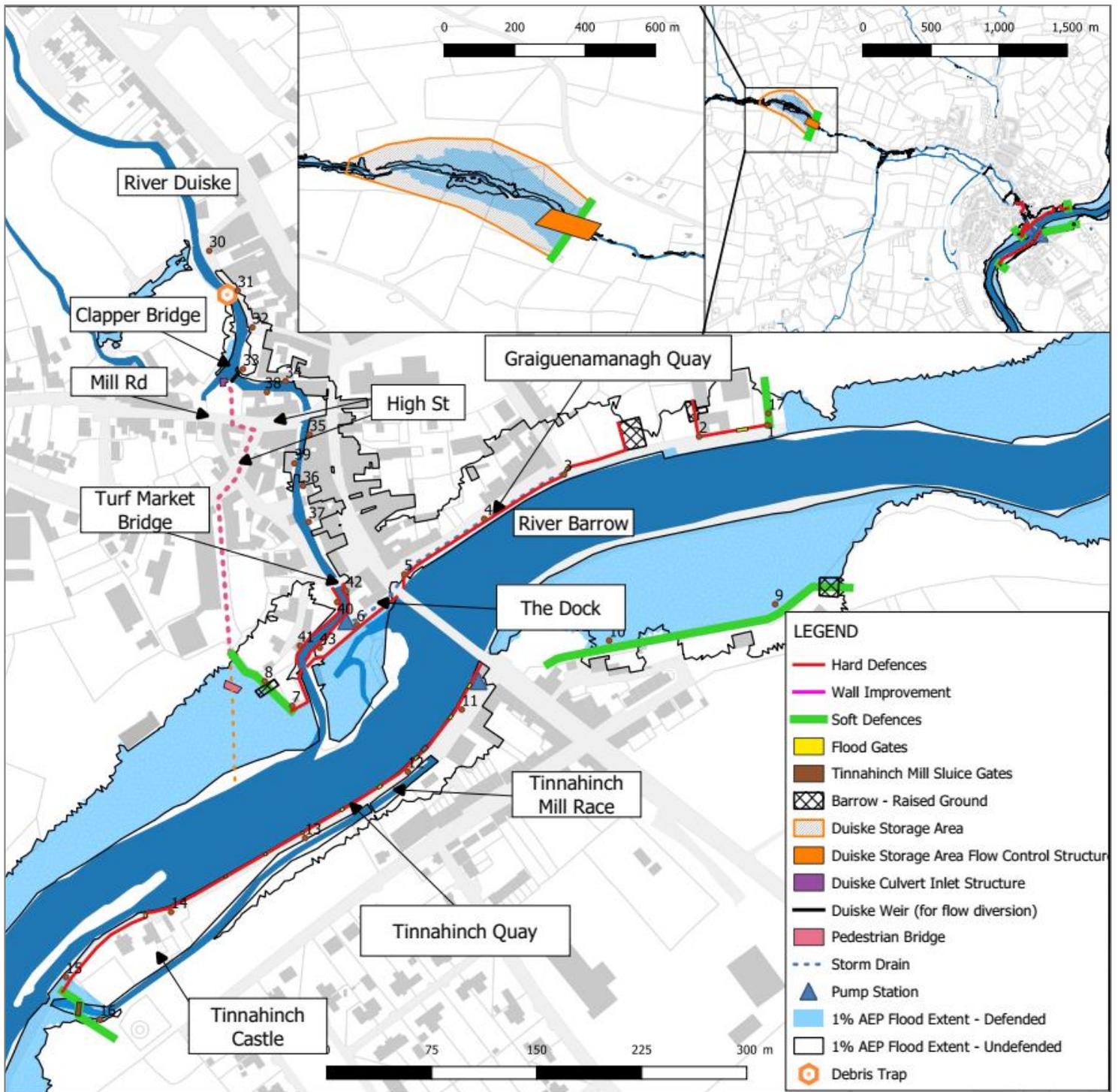


Figure 4: Option 4

Option 5 – Raised Defences & River Duiske Culvert

Description

Flood Defence embankments and walls form the defences on the River Barrow as shown in Figure 12. A sluice gate is provided on the Mill Race to Tinnahinch Castle at the upper and lower ends to control flows in this channel during flood events. Flood gates are required along Graiguenamanagh Quay and Tinnahinch Quay to retain access for water activities. Additionally, some local land raising areas are required to maintain access to properties. Back of wall stormwater drainage is also required along Graiguenamanagh Quay, and pumping stations will be required on both quays as shown.

Flood defence walls are required on both banks of the River Duiske but primarily on the eastern side. Wall improvement to existing structures/walls is required upstream of High Street Bridge, as well as a replacement pedestrian access bridge and some local land raising. A debris trap is located adjacent to Well Lane.

At Turf Market, walls are avoided downstream of High St. Bridge by installing a lid/culvert on the watercourse. A wall is required on the eastern bank opposite the old mill and a replacement bridge is required at this location also to prevent flooding over the bridge parapet.

Walls are required downstream of Turf Market Bridge on both banks where the influence of the River Barrow dominates.

Flood defence heights are based on the 1% AEP flood event, plus an allowance for freeboard – typically 300mm for walls and 500mm for embankments where settlement can occur over time.

The option would include the following defence heights and lengths. More precise wall heights for specific areas can be found on the drawings contained in the display posters.

River Barrow	Heights	Length
Flood Walls on Left Bank	0.9 – 1.2m	390m
Flood Embankments on Left Bank	0.8 – 1.4m	280m
Flood Walls on Right Bank	0.8 – 1.6m	372m
Flood Embankments on Right Bank	0.7 – 1.6m	101m
River Duiske		
Flood Walls on Left Bank	0.2 – 2.3m	264m
Wall Improvements on Left Bank	0.2 – 2.3m	16m
Flood Walls on Right Bank	0.2 – 2.3m	106m
Wall Improvements on Right Bank	0.2 – 2.3m	16m
Bridge Replacements	2no.	<10m
Culvert		47m

Left Bank = Left bank when looking downstream on the watercourse

Right Bank = Right bank when looking downstream on the watercourse

Benefits	Constraints
<p>Properties that previously flooded are protected.</p> <p>A key transport route from Carlow to Kilkenny is protected.</p> <p>The option is economically viable.</p> <p>Hard defence walls typically replace existing walls or man-made banks where possible.</p> <p>The option avoids permanent alterations to the watercourses and avoids all instream works in the River Barrow.</p> <p>Opportunity to enhance public areas of Graiguenamanagh Quay if works are integrated with Public Realm works.</p> <p>Defences do not impose overbearing solution on any particular property/landowner or group.</p> <p>Access to properties at Turf Market is readily achieved.</p>	<p>Density of cultural heritage features potentially affected is large and within the Archaeological Zone of Notification.</p> <p>Space for construction of culvert on left bank of Duiske at Turf Market is extremely limited.</p> <p>Defences are required within the SAC, particularly on the River Duiske.</p> <p>Mitigation of temporary in-stream construction impacts on SAC's Qualifying Interests is needed.</p> <p>There is a recognised preference among some members of the public to avoid raised defences in public areas such as Graiguenamanagh Quay.</p> <p>Flood gates are unavoidable at the access to Tinnahinch Castle and to the Rowing Club. These measures require a warning and deployment plan.</p> <p>Many properties have drains to the River Duiske which need non-return valves to prevent backflows to the properties.</p>

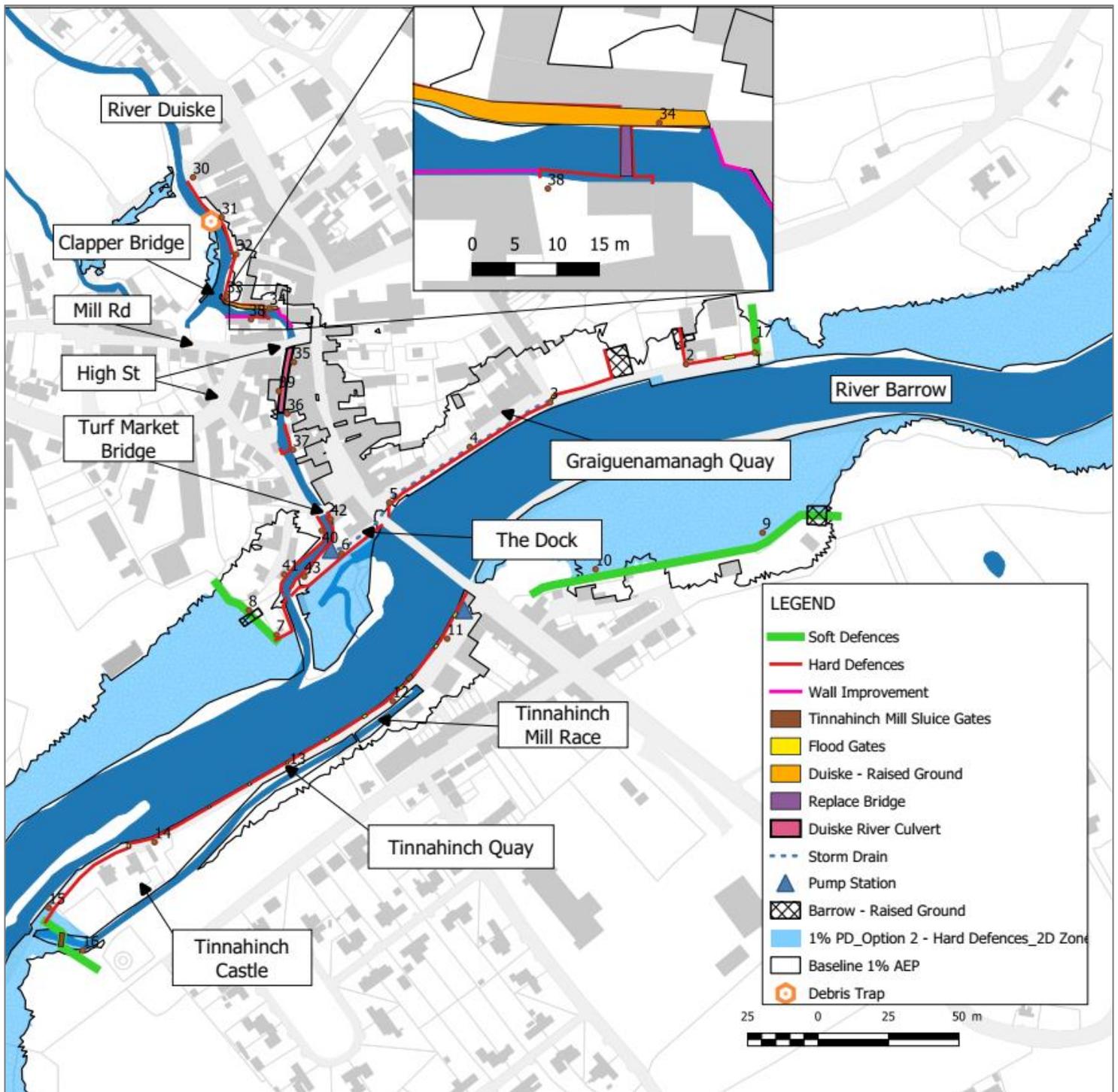


Figure 5: Option 5