COUNTY DONEGAL
FLOOD RELIEF SCHEMES

Comhairle Contae Dhún na nGall
Donegal County Council

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Project Ireland
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CASTLEFINN FLOOD RELIEF SCHEME

Option Development Report

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1 SCHEME ANALYSIS AND DEVELOPMENT

This report details the option development process for the Castlefinn Flood Relief Scheme, from flood risk assessment to screening of potential Flood Risk Management measures to selection and development of a preferred option which will form the Scheme.

1.1 Objectives

The Scheme Analysis and Development objectives are as follows:

- To identify options for Castlefinn (potential Flood Relief Schemes) that are economically viable, and environmentally acceptable while also being acceptable to the community and other stakeholders. Options must be effective in protecting the areas at flood risk within the community of Castlefinn against the flood event to the defined Standard of Protection (SoP).
- To identify the preferred option (the Scheme) that should be taken forward to Planning under Stage II of the Project with limited variation that may arise through the Planning and Detailed Design process and;

Within Stage I, the Scheme and its construction considerations should allow for a fully compliant Environmental Impact Assessment Report (EIAR) and Natura Impact Statement (NIS) (where required) to be prepared.

1.2 Previous Studies

Castlefinn was identified as an Area for Further Assessment (AFA) during the NWNB CFRAM Study (hereafter the CFRAM Study[1]) from 2012-2017. The CFRAM Study modelled the flood risk to Castlefinn town and developed options to provide a 1% Annual Exceedance Probability (AEP) / 100-year Standard of Protection (SoP).

Hard defences were identified as the only technically feasible solution that would provide the required protection to Castlefinn. This was due to the complexity of the flood mechanisms affecting Castlefinn AFA (see Section 1.4 for further detail on the flood mechanisms).

The preferred hard defence option at Castlefinn identified in the CFRAM Study is shown in Figure 1.1. This shows at-risk properties protected against flooding from the River Finn by a series of earthen embankments.

The CFRAM Study economic appraisal of the preferred option determined a Benefit-Cost Ratio (BCR) of 1.52 based on a whole life option cost of €1.74 million.

[1] Flood Risk Management Plan for the North Western River Basin (UOM01) (19/02/2018) available at:

https://www.floodinfo.ie/publications/?t=22&a=660

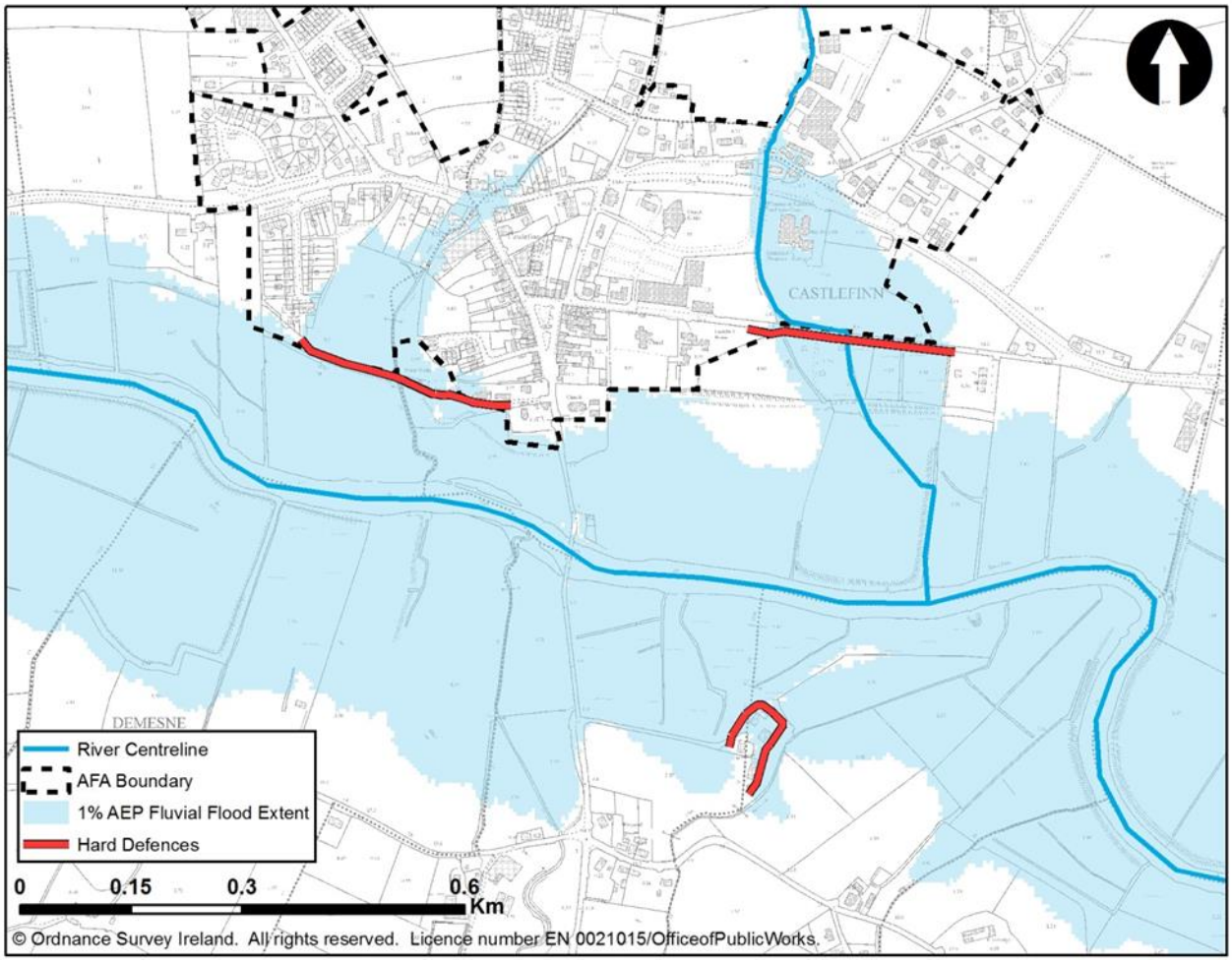


Figure 1.1 CFRAM Study Preferred Option, Castlefinn AFA (extracted from the Castlefinn Options Report from the CFRAM Study)

1.3 Target Standard of Protection

Castlefinn has a long history of flooding as discussed in the Castlefinn FRS Hydrology Report[2]. The most recent, large-scale flood events were in November and December 2015. They were noted to be between a 5% AEP and 1% AEP event and 2% AEP and 1% AEP, respectively. These 2015 flood events caused widespread flooding to residential properties and commercial properties including the Castlefinn Partnership Initiative (CPI) Centre, which hosts several locally important services. The Castlefinn FRS Hydrology Report reports a Qmed value of 257.9m^3/s and flows of 544.3m^3/s during a 1% AEP event, emphasising the huge amounts of water which must be contained.

The CFRAM Study hydraulic modelling and optioneering highlighted that proposed hard defences would protect Castlefinn from the 1% AEP fluvial event. The Steering Group confirmed that in line with the Project Brief the target SoP for the Castlefinn FRS is the 1% AEP present-day flood event scenario.

[2] Castlefinn Flood Relief Scheme Hydrology Report, document no. IBE1760_Rp019 (RPS,2022) available at: https://countydonegalfrs.ie/castlefinnfrs/index.php/documents

The process and procedures for developing the baseline hydraulic modelling for the Castlefinn Flood Relief Scheme (FRS) are detailed fully in the Castlefinn FRS Hydraulics Report3. The baseline hydraulic model was used to analyse the existing level of flood risk at Castlefinn. The 1% AEP present-day flood event at Castlefinn is shown in Figure 2.1.

The model showed that flooding occurs in Castlefinn primarily from the River Finn. Flood risk also emanates from the Bridge Burn and Castlefinn Watercourse, two tributaries of the River Finn that flow through Castlefinn Town. Flooding on these tributaries is influenced by water levels in the River Finn.

[3] Castlefinn Flood Relief Scheme Hydraulics Report, document no. IBE1760_Rp015 (RPS,2022) available at: https://countydonegalfrs.ie/castlefinnfrs/index.php/documents

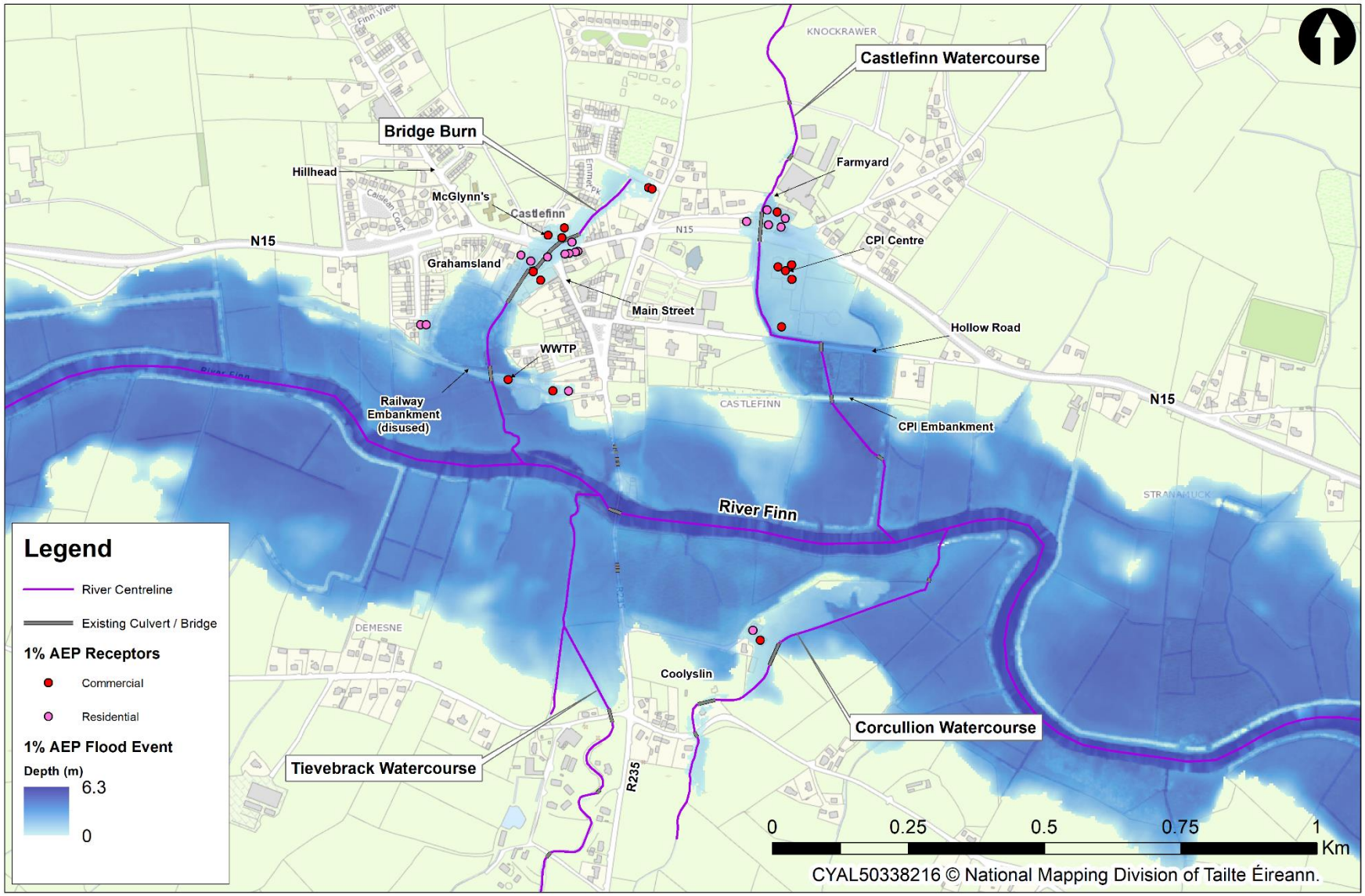


Figure 1.2 1% AEP Present-Day Flood Extents and Properties at Risk, Castlefinn

1.4 Existing Defences and Option Modelling Baseline

Following flooding in 2015 a flood defence structure was constructed along the old railway line, downstream of the CPI Centre. The defence in Castlefinn is shown in Figure 1.3.

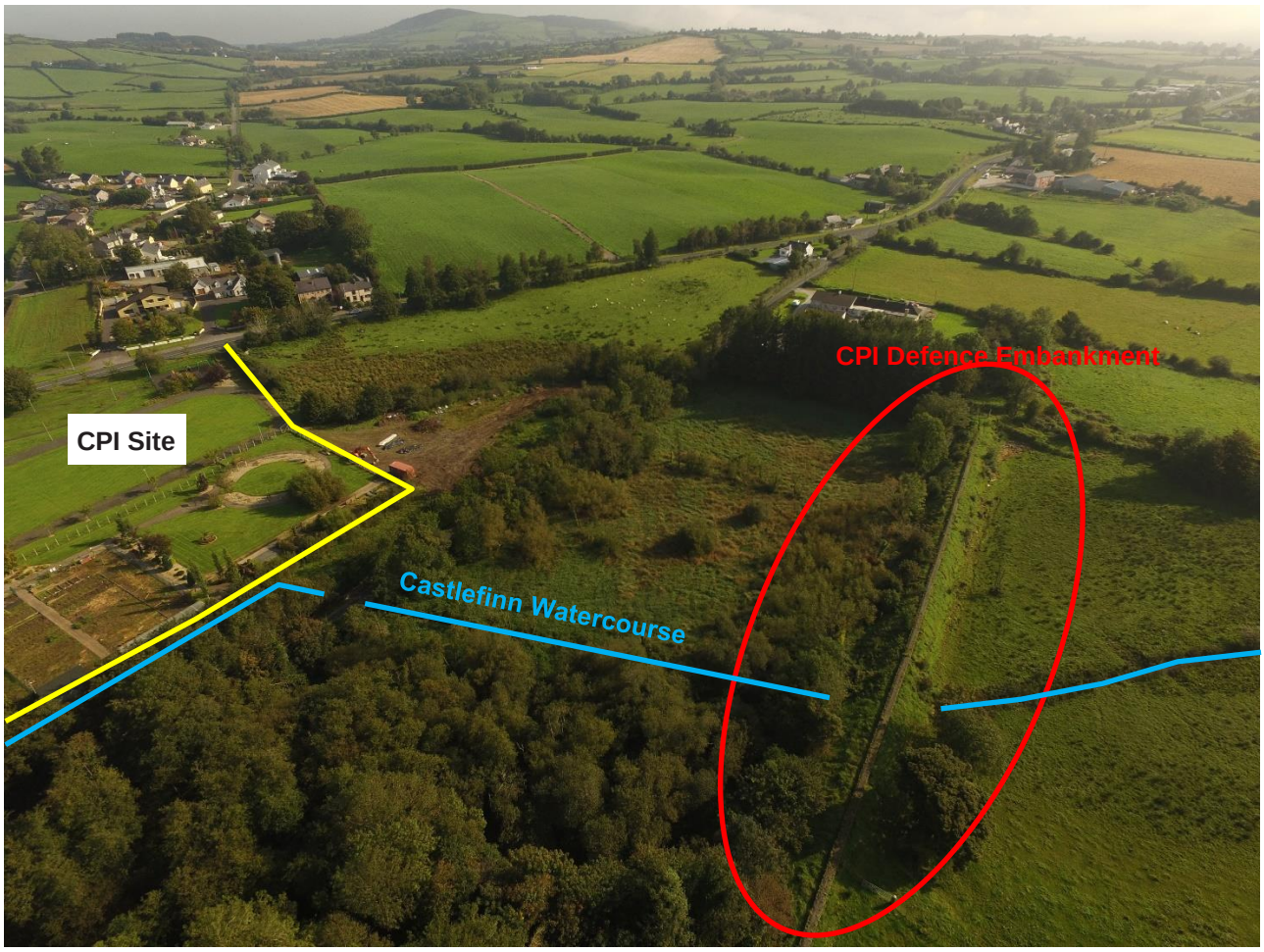


Figure 1.3 Existing flood defence downstream of the CPI Centre, view looking north

The construction of the flood defence was coordinated by the CPI in response to the flood events in November and December 2015. It is designed to prevent flood waters from the River Finn from flooding the CPI Centre. The Castlefinn Watercourse flows through the flood defence via a culvert. The outlet is controlled with a flap valve to prevent backwater flooding from the River Finn.

At the time of its construction, the CPI and its representatives liaised with the CFRAM Study to ascertain predicted design flood levels. The crest of the old railway embankment was raised to achieve a consistent elevation and profile. A cellular flood barrier system was then placed on top to bring the structure crest above the CFRAM Study 1% AEP design flood level.

The treatment of the CPI defence embankment within the hydraulic analysis is set out in Section 3.1.4.4 of the Hydraulics Report. The embankment was treated as fully effective with the flood cells on top treated as permeable. This was considered to represent its expected present-day performance.

Following baseline hydraulic analysis, it became apparent through an initial flood risk assessment that the approach resulted in reduced flood extent and associated damages estimated for the CPI centre and properties on the eastern side of Castlefinn generally. Discussion with the Steering Group concluded that this was unrealistic over the design life for the Castlefinn FRS for the following reasons:

- The makeup of the historic railway embankment is unknown. Therefore, its structural performance cannot be assessed.
- The side slopes of the embankment are very steep (up to a 1-in-1 slope). These are difficult to maintain and are at high risk of failure in the future as a result.
- The watercourse culvert screen and flap valve are susceptible to blockage and are unmaintainable in their current form.

The hydraulic baseline model showed that flood water would permeate through the flood cells at the top of the flood defence structure during a 1% AEP flood event. It is considered that over time the structure would fail and would become totally ineffective unless it is re-constructed.

Therefore, for the Option Development phase of the project, the baseline model was amended to treat the embankment as ineffective. This was achieved by flattening the embankment to a crest level of 5.5m OD Malin which represents a failure of the top half to two-thirds of the earthen structure.

A new suite of baseline model outputs reflecting this change was used for assessing damages/benefits for the scheme and was adopted as the basis for this report. Existing flood risk is described with the CPI embankment in situ.

2 FLOOD RISK ASSESSMENT

2.1 Flood Mechanisms

The flooding mechanisms that result in out-of-bank flooding and flood risk to properties in Castlefinn are described in full in the following sections. The flood mechanisms have been labelled according to the watercourse that the flood risk emanates from.

2.1.1 Flood Mechanisms: River Finn

The majority of flooding at Castlefinn is driven by the flood levels in the River Finn. During all flood events, channel capacity is reached, out-of-bank flooding occurs, and the Finn floodplain is activated. Water levels in the River Finn are driven by two sources. Firstly, catchment runoff from the River Finn is estimated to generate river and floodplain flows of approximately 540 m^3/s during a 1% AEP event. This mechanism is referred to in this report as River Finn 1. Secondly, flood levels are driven by a backwater effect from the River Foyle downstream. When flood conditions occur in the large and flashy Mourne catchment, the main contributor to the Foyle, it causes a backwater effect from the confluence at Lifford up the flatter, lower reaches of the River Finn. This causes rising water levels or even a backflow effect observed at Castlefinn. This mechanism is referred to in this report as River Finn 2.

These two sources of flooding combine during flood events to drive high flood levels at Castlefinn. Low-lying areas of Castlefinn are impacted. This includes properties sitting low in the Finn Valley and at the lower reaches of tributaries of the Finn. In a 1% AEP event flood waters reach up to a level of approximately 7.5 metres above ordnance datum (mAOD) directly flooding two properties to the south of the river in the floodplain at Coolyslin (location depicted in Figure 3.1).

A flood defence (earth embankment) lies along the old railway line in Castlefinn, downstream of the CPI Centre. This delays the inundation of the flood waters and provides for activation of the River Finn floodplain behind it. However, during the 1% AEP present-day flood event, the flood waters overtop the existing defence and flood the CPI centre and surrounding properties up to levels of approximately 7.4mAOD. Similarly, the remnants of the old railway embankment at the east of the town are overtopped during the 1% AEP event leading to flooding in the housing estate at Grahamsland and at the junction of the N15 and Main Street (outside McGlynn's).

2.1.2 Flood Mechanisms: Bridge Burn

Out-of-bank flooding occurs upstream of the inlet and from the manholes of the Bridge Burn watercourse culvert that passes under the N15 in front of McGlynns restaurant. CCTV survey identified the culvert as severely blocked (70%-90% blockage) and cannot convey any significant flow rates generated upstream in the Bridge Burn catchment. This mechanism is referred to in this report as Bridge Burn 1.

Flooding from the Bridge Burn is also driven by flood levels in the River Finn which come back up along the Bridge Burn watercourse and culvert. This mechanism is referred to in this report as Bridge Burn 2.

Flooding from the Bridge Burn affects commercial properties (i.e., McGlynn's), residential properties and the N15 road at its junction with Main Street.

2.1.3 Flood Mechanisms: Castlefinn Watercourse

Out-of-bank flooding occurs on the Castlefinn Watercourse adjacent to the farm, upstream of the culvert under the N15. CCTV survey identified the culvert as partially blocked in places (30%-40%). The culvert is a low stone arch at its inlet. The inlet is 750mm in height which then transitions into a larger 900mm diameter concrete pipe.

The cumulative effect of the culvert being undersized, its condition and blockages mean that during a flood event, this mechanism causes elevated food levels in the open watercourse upstream of the N15. This results in out-of-bank flooding on the left bank through the farm and to properties on both sides of the N15, including the CPI centre.

Flooding from the Castlefinn watercourse is heavily influenced by flood levels in the River Finn. As water levels rise in the River Finn floodplain, a flap valve on the Castlefinn watercourse under the defence embankment downstream of the CPI Centre is forced closed. This operation prevents water from discharging from the Castlefinn Watercourse into the River Finn. This results in flooding to the low-lying land behind the defence embankment. Over time runoff from the Castlefinn watercourse builds in this area eventually flooding the lower parts of the CPI Centre site. The backwater effect from the closed flap vale also combines with flood flows from the upper watercourse catchment to cause out-of-bank flooding from the watercourse adjacent to the CPI site. These flooding mechanisms are referred to in the measures screening as Castlefinn Watercourse 1 (driven by catchment flows) and Castlefinn Watercourse 2 (driven by River Finn backwater levels).

2.1.4 Other sources of flood risk

There are numerous historic reports of pluvial flooding at Castlefinn mostly on the N15 in front of McGlynn's restaurant at the junction of the N15 and Main Street. Flooding at this location is a combination of fluvial, pluvial and the failure of the drainage system / Bridge Burn culvert. The model is replicating frequent flooding at this location following the implementation of the recorded blockage in the culvert ascertained through the culvert and CCTV surveys.

At the Design Review Collaborative Workshop (29/04/22) a representative from DCC Roads section noted there have been reports of flooding to the An Post office and shop at the bottom of Hillhead Road where it meets the N15. This has been reviewed and discussed with the Steering Group. It is considered to result from pluvial runoff accumulating on the steep Hillhead Road which is not being intercepted by local drainage systems. This flood mechanism is not being considered in the FRS Option Development. DCC are investigating the issue and have planned further surveys and maintenance works to improve the performance of the drainage system.

2.2 Flood risk

An assessment of the flood risk was carried out for Castlefinn. Table 2.1 highlights the properties at risk of flooding during a 1% AEP flood event.

Table 2.1 Properties at Flood Risk in 1% AEP Flood Event, Castlefinn

Recep/Asset affected	Number of properties/assets at risk	Impact of flooding
Residential properties	17	Monetary damage – direct and indirect
Commercial properties	16	Monetary damage – direct and indirect
Utility Assets	1	Wastewater Treatment Plant
Roads	3	N15 (Lifford – Stranorlar), R235 (Main Street) and Hollow Road. In addition, several local accesses are affected.

Figure 2.1 displays the properties at flood risk across Castlefinn during a 1% AEP present-day flood event. This highlights the damage associated across the scheme area, with particularly acute flood impacts on the N15 road and several residential and commercial properties in the flood plain of the River Finn and Castlefinn Watercourse.

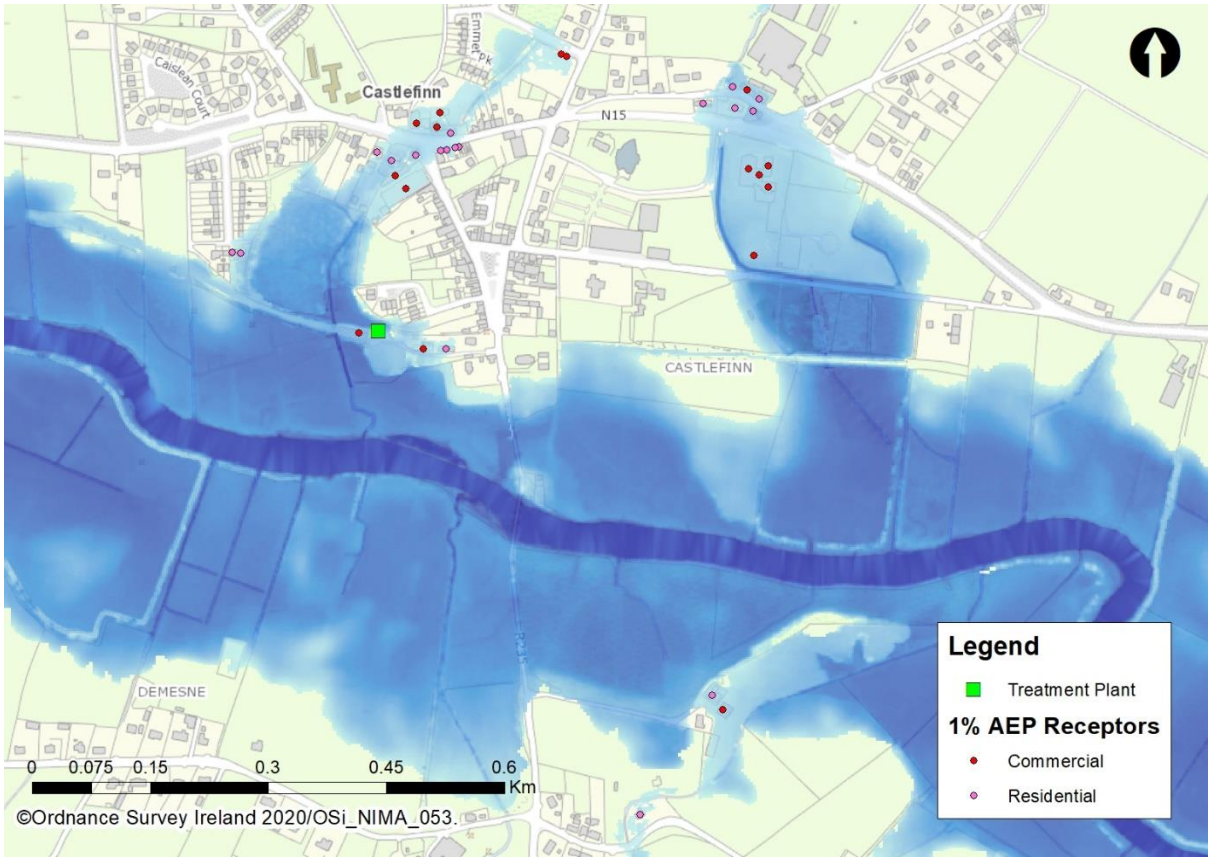


Figure 2.1 Properties at Risk in 1% AEP Present-Day Flood Event, Castlefinn

2.3 Constraints

2.3.1 Environmental constraints

The key environmental constraints[4] identified for Castlefinn are:

- The River Finn is a designated salmonid river and Special Area of Conservation (SAC), as well as an important migratory route for European Eel and lamprey. The proposed Scheme must ensure the conservation of the Atlantic salmon is considered.
- Due to the sensitive nature of the aquatic life in the waterbody, all in-stream works should be carried out during the period from May to September.
- Terrestrial ecology field surveys identified the potential for otters, Daubenton's Bat and badger. These must be taken into consideration.
- Japanese knotweed is a key environmental constraint due to its location along the proposed defence route of the scheme in the proximity of the existing wastewater treatment plant (WwTP). Other invasive species found within the study area and representing constraints to the scheme include giant hogweed.
- The proposed Scheme may increase the impact on the hydromorphology of the waterbodies which is currently listed as a contributing element preventing the water bodies from achieving their EU WFD objectives.
- Construction impacts will be a key consideration as pollutants can impact on the biological and physicochemical elements of WFD status.
- Overland flow or drainage ditches will be the main pathway for contaminants to enter the water environment and will need to be managed as such during the construction and operation of the proposed Scheme.
- Noise during the construction phase of the proposed Scheme may have a temporary local adverse impact on the environment and migratory fish.
- Buildings or structures of significance include those that have been identified to be at risk of flooding and the private flood defence structure constructed by a third party along the alignment of the old railway line to the east of the Town Centre south of Hollow / Chapel Road (CPI embankment).
- Buildings of architectural and cultural heritage significance, including Castlefinn Bridge and the Castle, are key constraints.

[4] Castlefinn Flood Relief Scheme Constraints Study, (RPS, 2021) available at: https://countydonegalfrs.ie/castlefinnfrs/index.php/environmental-assessment/

- Given the heritage significance of Castlefinn, a more detailed archaeological evaluation process and subsequent Environmental Impact Assessment will be undertaken to ensure the known and standing monuments, architectural and cultural heritage sites are avoided. Specific mitigation requirements to address potential 'unknowns' can only be identified as items for review once the location of any chosen preferred option is defined.

2.3.2 Utility infrastructure

There is Irish Water Sewer and Water infrastructure in the Castlefinn area. This mainly consists of a Wastewater Treatment Plant (WwTP) near Grahamsland, watermains and sewers. These mainly run along the road networks but also through private property to reach the WwTP near Grahamsland. Where the Flood Relief Scheme crosses a road or is located in the vicinity of the WwTP, it is anticipated that there will be a clash with Irish Water infrastructure. The Flood Relief Scheme will be required to protect the WwTP without inhibiting its operation, as it services the Castlefinn agglomeration and is located immediately behind the proposed Scheme.

Other infrastructure constraints noted are an Eircom DSL exchange in the village of Castlefinn and the N15 also represents the Eircom broadband backbone network and transport link.

There is also significant underground and overhead low and medium voltage electricity infrastructure in Castlefinn. The mapped utilities in the centre of Castlefinn are shown in Figure 2.2.

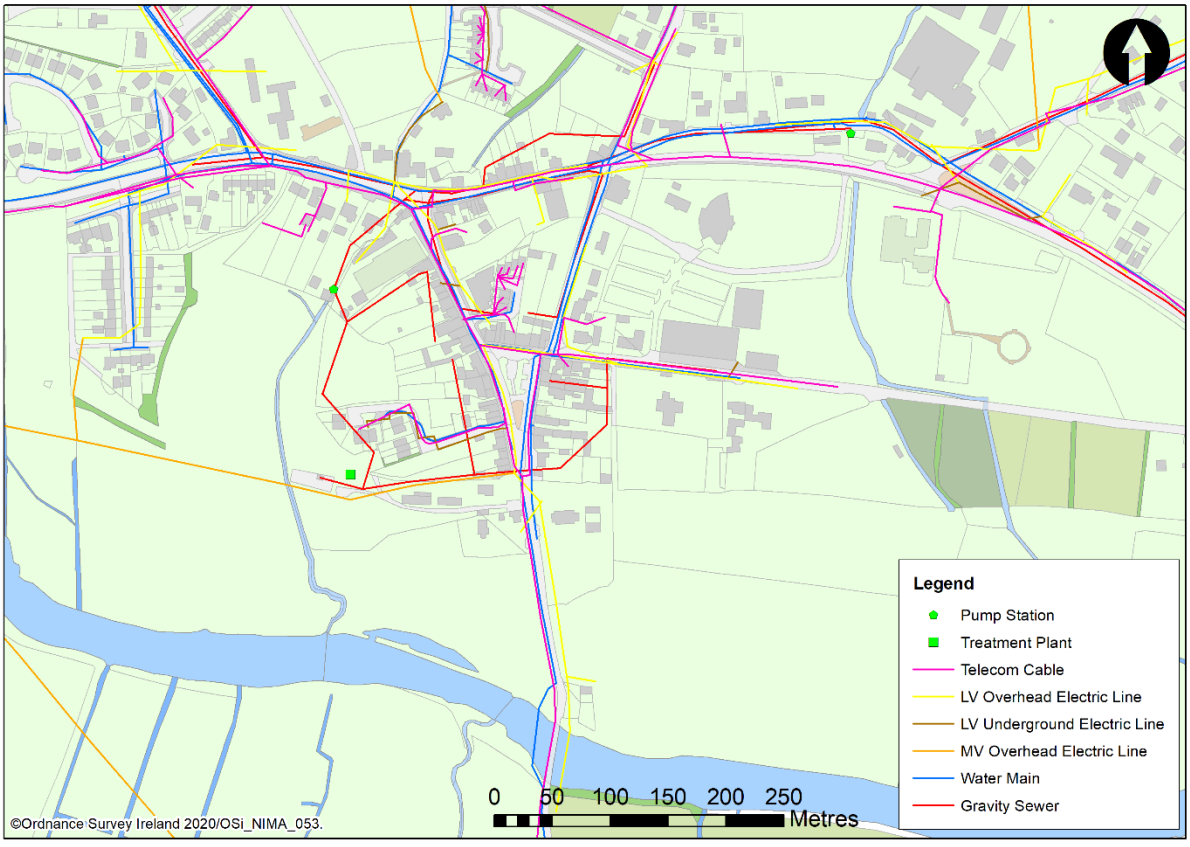


Figure 2.2 Mapped utilities in Castlefinn

2.3.3 Ground condition constraints

A review of national soil datasets was conducted to give an indication of the soil condition at Castlefinn. The Irish Soil Information System (SIS) dataset provides details of soil type and soil drainage and was used as the primary dataset.

The primary soil type in Castlefinn is Loam underlain by Till. The loamy soil is expected to drain well. However, the River Finn Corridor is primarily River Alluvium which is expected to have poor drainage.

The Castlefinn FRS has the potential to be located in both soil types (Loam and Alluvium). The soil drainage indicates that the soil porosity will affect the design of the flood defences and the extent of the cut-off required to reduce seepage across the defence.

Further ground investigation will be undertaken/planned prior to the construction stage.

2.3.4 Access constraints

The options development needs to consider any access constraints that may exist to any potential flood defences proposed, the watercourses and any properties, buildings, or property boundaries.

The access constraints to the Finn floodplain are fairly limited. There are no access constraints to the areas where defences will potentially be built. However, permission from landowners will need to be granted to access across agricultural land. Permissions will be necessary across many stages of the Castlefinn FRS including ground investigation for mobilisation, construction, operation and maintenance and for all relevant machinery which may be required.

Access to the Bridge Burn for the proposed defences and upgrades (i.e., culvert upgrade) may be limited. The Bridge Burn culvert is close to properties and property boundaries on both sides of the N15. The existing culvert route downstream of the N15 flows under a residential property garden. Any upgrade, modification and further maintenance would need to consider the restricted working space and disruption to any landowners.

Access constraints to the culvert on the Castlefinn Watercourse also need to consider the proximity of properties and property boundaries north of the N15. Similarly, any upgrade, modification and further maintenance would need to consider the restricted working space and disruption to any landowners.

Figure 2.3 shows the access constraints that may exist at Castlefinn.

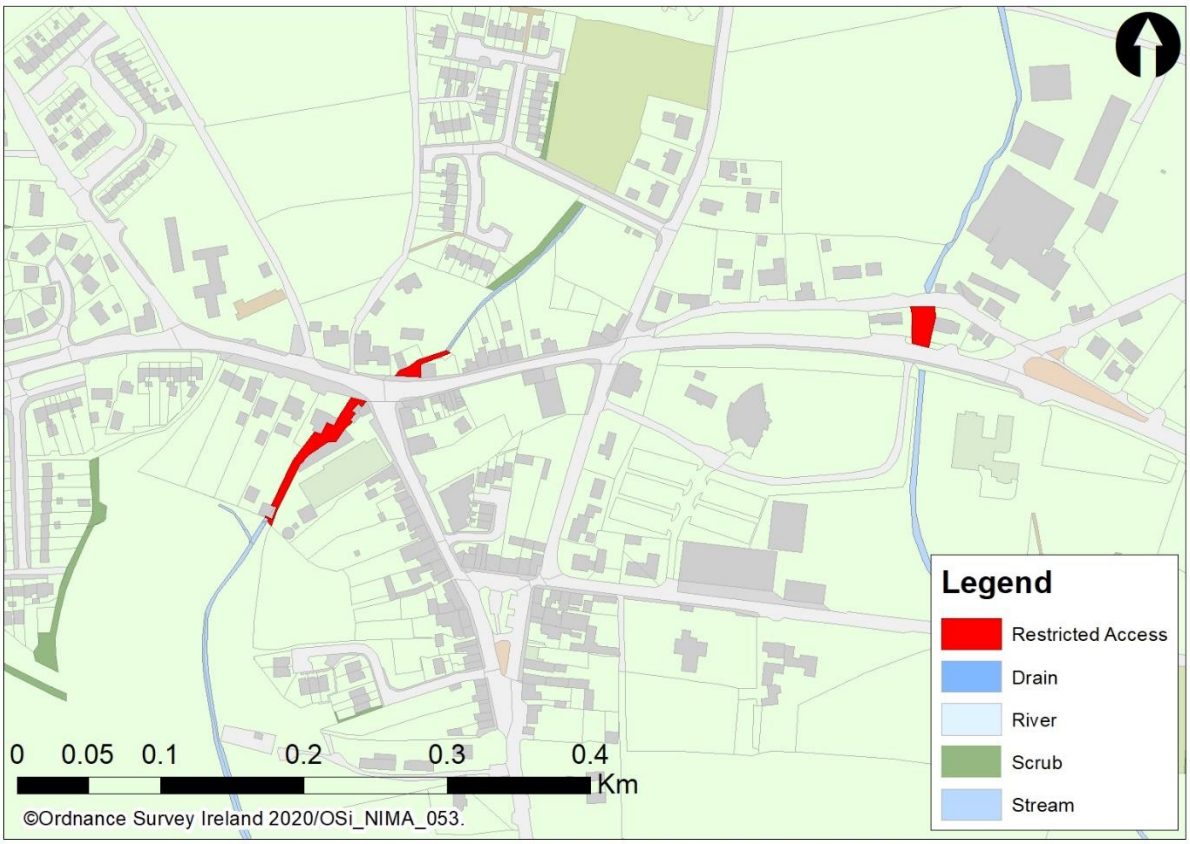


Figure 2.3 Access Constraints, Castlefinn

2.4 Opportunities

The potential concurrent opportunities for the Castlefinn FRS are fairly limited at this stage. Donegal County Council is currently considering the feasibility of constructing a Lifford to Castlefinn Greenway to connect the two towns through an environmental corridor.

Option development should consider this opportunity and identify if potential greenway routes are restricted as a result of the option proposed.

Moreover, from the site visit the WwTP clearly needs an upgrade. Uisce Éireann, working in partnership with Donegal County Council, is investing €1.4 million to commence essential upgrade works to wastewater treatment plants across Donegal, including Castlefinn (Uisce Éireann, 2023[5]). Works involve inlet upgrades, storm water management and sludge treatment and storage at the plants.

[5] https://www.water.ie/projects/local-projects/donegal-countywide-wastew/

3 SCREENING OF MEASURES

In screening the measures for Castlefinn each measure was considered against each of the flooding mechanisms identified in Section 2.1.

A screening of the flood management measures as defined in the brief was carried out and is summarised in Table 3.1. No other measures were identified for consideration.

Do nothing was screened out as it does not contribute to meeting the objectives. Maintenance or sediment issues were not identified as a flooding mechanism therefore sediment deposition and trap measures were screened out. The tidal barrage was screened out as the flooding mechanisms identified are fluvial. Diverting the River Finn and constructing a flood bypass channel on the Finn are both screened out due to the nature of the flood mechanism (driven from both upstream and downstream) as well as the massive technical and environmental challenges involved with such large scale works on the River Finn.

Table 3.1 Initial Screening of flood management measures

Measure	River Finn	Bridge Burn	Castlefinn Watercourse
Do nothing	✗	✗	✗
Relocate/Reconstruct properties	✓	✓	✓
Divert river	✗	✓	✓
Flood bypass channel	✗	✓	✓
Upstream flood storage	✗	✓	✓
Walls & Embankments	✓	✓	✓
Increase conveyance	✗	✓	✓
Sediment deposition and traps	✗	✗	✗
Tidal barrage	✗	✗	✗

In addition to the measures listed in the table above, the following other measures are considered viable for flood relief schemes: Flood warning system; Individual Property Protection; Restricting development of floodplain; Demountable defences and Pumping of stormwater from behind flood defences. These measures do not directly address the flooding mechanisms identified but can complement other measures in providing a more sustainable option. These measures were not taken through the screening process but are available during the option development stage to be added to any option if deemed appropriate.

Measures that would reduce the flow in the River Finn or measures that would improve the conveyance of the River Finn cannot provide the target SoP. While these measures would address flood mechanism River Finn 1 to some degree, they would have no significant impact on flood mechanism River Finn 2. Therefore, only measures which contain the flood water or directly modify the risk to the properties at risk were considered appropriate (i.e., walls and embankments).

The flooding from the tributaries is partly caused by the water levels in the River Finn. Measures on the tributaries would need to account for the measures applied on the River Finn.

Assuming a containment approach on the River Finn, any flow trying to discharge from the Bridge Burn and Castlefinn Watercourse through the defence line will be prevented while the River Finn levels are high (as described in flood mechanisms for Bridge Burn 2 and Castlefinn Watercourse 2). Measures which can convey and contain the tributary flood flows and volumes on the defended side of the River Finn or measures that can reduce the flow in the tributaries would be applicable.

Upstream catchment management, also known as Nature-based Solutions for Catchment Management (NbS-CM), was considered as part of the NbS feasibility study and is considered further in Section 6.1.

Where required, the screening of measures in the long list was assessed by representation in the Castlefinn hydraulic model. This included measures such as walls and embankments, upstream storage and increasing conveyance. Details of how measures were modelled are provided in Appendix B.

3.1.1 Relocate and Reconstruct Properties

These measures consider relocating properties out of the floodplain. This may be achieved if the property can be physically moved or demolished and re-constructed in a suitable location.

Relocation considers single or groups of properties that can be relocated out of the risk area to a suitable location. When considering which properties would be suitable for relocation social, technical, and economic factors were considered. Such factors included:

- Would removing properties have a detrimental impact on the local community;
- Are there other suitable areas zoned to accommodate the relocation;
- Would the cost be disproportionate to the present-day damage from flooding;
- Public safety - especially in areas where there may be deep fast flowing water during a flood event;
- Potential to ease restrictions on the development of other options e.g., to make space for defences or flood storage/conveyance improvements as part of structural solutions.

When assessing which properties may be suitable for relocation, the market value of the property was considered against the damage which the property may incur through flooding. Properties were considered suitable for relocation if the damage they may incur through flooding was greater than their market value.

In Castlefinn, relocation of properties at risk to the north of the River is not socially acceptable. The properties are located within the continuous fabric of the settlement of Castlefinn. Their relocation would result in holes in the urban settlement and break up the community. The cost of relocating all the properties (31) in the town is also not economically viable.

Two properties, one residential and one commercial, to the south of the River Finn at Coolyslin (that sit adjacent to the Corcullion Watercourse) were identified as properties that could feasibly be relocated out of the floodplain. These properties are highlighted in Figure 3.1.

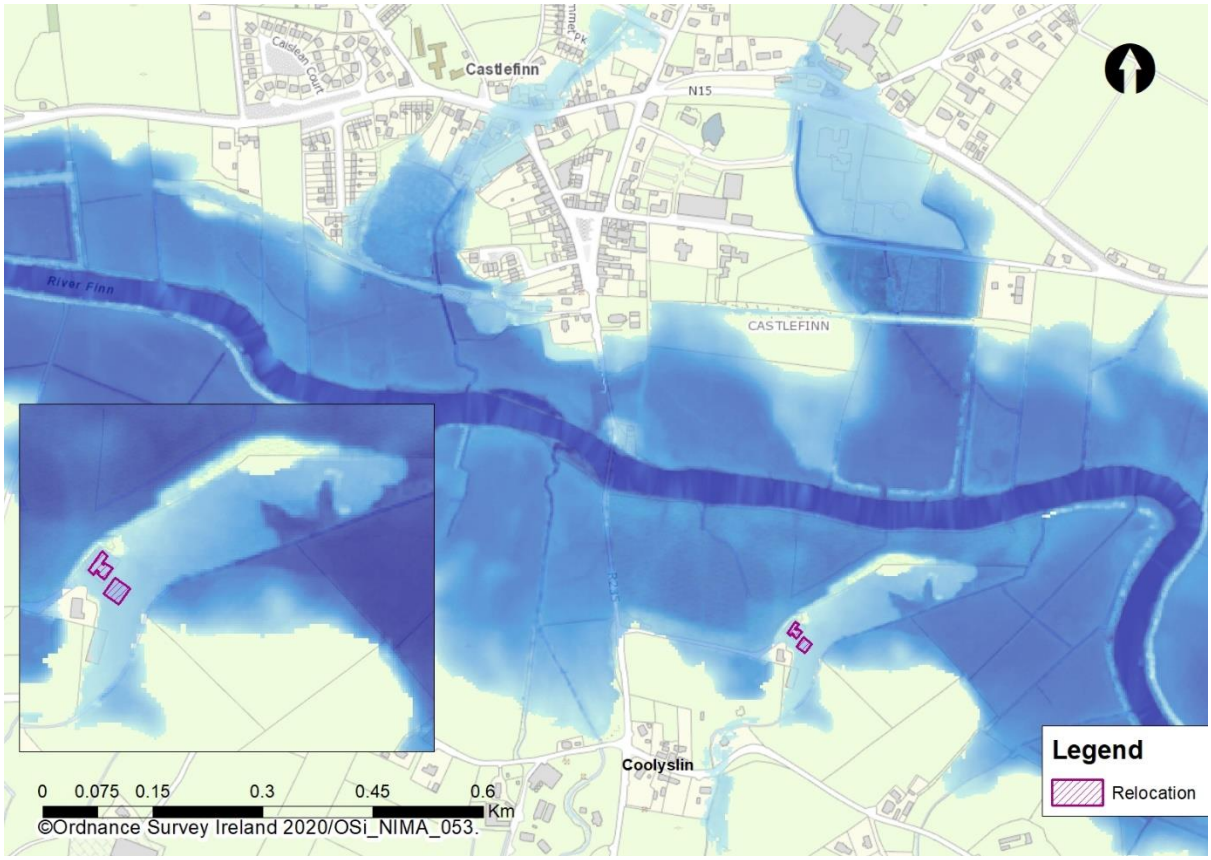


Figure 3.1 Properties that could be feasibly relocated, Castlefinn

This measure also considers reconstruction of at-risk properties. This would involve the reconstruction of buildings to make them flood resilient or raising them above the flood level. It would be anticipated that there would still be a certain amount of flood risk with service disruptions, clean-up costs and emergency and evacuation issues. Reconstruction is not considered further as it doesn't provide the full SoP and other more suitable measures are available for Castlefinn.

3.1.2 River Diversion and Flood bypass channel

River diversion and flood bypass channels were considered for the Bridge Burn Stream and the Castlefinn Watercourse.

Diverting would consist of constructing a new channel or culvert network which would convey the full flow of the watercourse. The reach of the watercourse downstream would become redundant. A flood bypass channel would be similar but only be required to convey the flood flows of the watercourse. The flood bypass channel would therefore not need to be as large as a full watercourse diversion and the reach of the river downstream would remain active.

A Geographic Information System (GIS) analysis of the catchment topography was carried out to ascertain if a diversion route is available. The Bridge Burn flows through a relatively deep valley with no suitable diversion route available. The Castlefinn Watercourse has a flat mid-catchment providing opportunities to direct flow into the adjacent catchment (to the east) and into an existing watercourse. A river diversion and flood bypass channel were therefore considered technically feasible on the Castlefinn Watercourse.

The diversion route would require at least 500m of new channel to be constructed and the potential widening of 1,200m of existing watercourse channel to the east of the Castlefinn watercourse. It would likely require upgrade of the existing watercourse culvert under the N15 to the east of the town to facilitate the potential doubling of flood flows in the watercourse. The diversion of flows into the watercourse catchment to the east of the Castlefinn watercourse would result in potential impacts to at least 12 landowners along the route of the watercourse resulting from increased flows. This watercourse was not subject to survey, hydrological and hydraulic analysis under the project and therefore the full impact could not be assessed. However, the measure was considered too technically complex and was not considered further.

Diversion and flood bypass routes across Castlefinn were therefore screened out.

3.1.3 Upstream Storage

Upstream storage was considered for the River Finn, Bridge Burn and Castlefinn Watercourse. Where suitable storage areas are available flood water can be stored during a flood event reducing flows and volumes of water flowing through the areas at risk. In screening for upstream storage, various criteria need to be met. The upstream catchment needs to be able to provide suitable storage locations. The upstream catchment needs to be able to generate sufficient flood flows relative to flood flows at the risk area such that enough can be removed through storage. These criteria were considered in the technical screening of upstream storage for all watercourses.

Attenuating the 1% AEP flood hydrograph on the River Finn down to the 50% AEP equivalent (that required to remove the majority of property flooding) would require more than 16 million cubic metres of storage. A model simulation of the 50% AEP fluvial flows with the 1% AEP downstream boundary (extracted from the Lifford FRS model) found that most of the properties at risk in Castlefinn were still at risk. Upstream storage for the River Finn was screened out as it cannot provide the required SoP due to the secondary mechanism of backwater emanating from downstream, to be found upstream of Castlefinn. Given this would not provide the required SoP, the measure was screened out as not technically viable. The backwater flood mechanism (Finn 2) is driven by a combination of water levels in the River Foyle and the high-energy Mourne catchment system dominating water levels at the confluence with the River Finn during flood events. These are regional scale, naturally driven hydrological conditions. There are no viable Flood Risk Management measures to mitigate this flood

mechanism. This was explored at the River Finn – Deele sub-catchment Spatial Scale of Assessment as part of the North-Western Neagh Bann CFRAM Study[6].

An upstream storage solution for the Bridge Burn was screened out following a review of the watercourse survey data. The culvert conveying the Bridge Burn under the N15 at McGlynns is in a very poor state with a loss of cross section and conveyance capacity of up to 90%. The watercourse culvert is close to complete failure which is likely to be achieved early in the design life. Measures for the Bridge Burn must therefore include Increased Conveyance (Section 3.1.5). Upstream Storage can only provide the required SoP if the conveyance capacity downstream is provided. If the culvert must be reconstructed to provide the conveyance capacity then the only benefit of providing Upstream Storage is to reduce the size of pipe needed for the new Bridge Burn culvert. Upstream Storage on the Bridge Burn is therefore screened out unless it is determined that there is a need to reduce the size of the new Bridge Burn culvert.

A GIS analysis of the catchment topography was carried out to ascertain if there were any suitable areas to provide flood storage upstream in the Castlefinn watercourse catchment. The watercourse has a topographically suitable middle catchment that would allow for upstream storage. The middle catchment has natural hollows and provides relatively flat areas of land which are suitable for flood attenuation.

A suitable storage area was identified upstream on the Castlefinn watercourse based on GIS analysis of the 5m IfSAR national digital terrain model (shown in Figure 3.2). Higher resolution LiDAR data was not available for the area outside of the lower part of the Finn Valley. Based on the IfSAR data a GIS analysis determined the storage volume available at each contour from the base up of the identified topographical depression to be used for storage. The storage area was defined within the hydraulic model as a 1D storage unit. A 2m high embankment, culvert and weir at the downstream extent of the storage area provided the flow control to attenuate flow. A further location for a smaller storage area (at the CPI Centre) was also identified and modelled for this area. This is an area of ground immediately to the east of the CPI site. Removal of material and regrading the floodplain here would result in an effective storage volume of 4,140m^3.

The measure cannot reduce all risk to properties arising from backwater effects from the River Finn but was found to sufficiently store flood waters from the 1% AEP event when used in combination with hard defence-type measures protecting from the River Finn. The upstream storage area sufficiently attenuates flow and stores flood waters in the upper catchment. The lower storage area, along with existing depressions, accommodates the residual flood volume from the Castlefinn watercourse while the watercourse is prevented from discharging through the Finn hard defences due to high levels in the

[6] North Western - Neagh Bann CFRAM Study UoM 01 Preliminary Options Report (RPS, 2016) accessed on 25/07/2023 at:

https://s3-eu-west-1.amazonaws.com/docs.floodinfo.opw/floodinfo_docs/NWNB_CFRAM/_UOM_01/06_PreliminaryOptions/IBE0700Rp0017_UoM01_Preliminary_Options_Report_F02_Merged.pdf

River Finn. Upstream storage, therefore, screened in for the Castlefinn Watercourse but must be used in combination with defences on the River Finn to address Castlefinn Watercourse 2 flood mechanism.

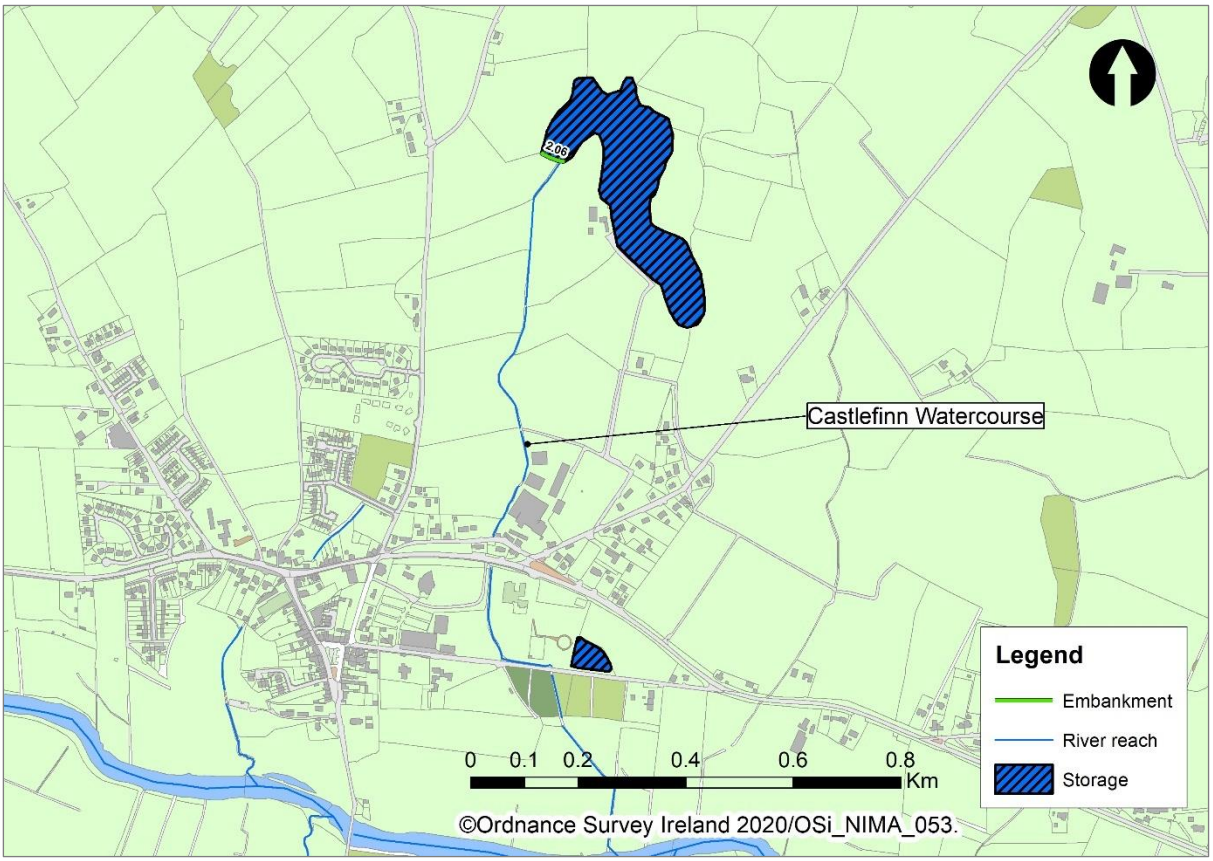


Figure 3.2 Potential Upstream Storage Location on the Castlefinn Watercourse

3.1.4 Wall and Embankments

Direct defences in the form of flood walls or embankments could be used to provide the target SoP. Direct defences would address the flood mechanisms on the River Finn and the secondary flood mechanism to the east of the town arising from the Castlefinn watercourse. However, the measure cannot address flooding from the Bridge Burn caused as a direct result of the blocked culvert under the N15 at McGlynns.

Direct defences are technically viable in four locations as shown in Figure 3.3 (numbered on figure):

1. To the west along the old railway embankment to protect against flooding from the River Finn (River Finn 1, 2 and Bridge Burn 2).
2. To the east of the town along the old railway embankment/CPI defence to protect against flooding from the River Finn (River Finn 1, 2 and Castlefinn Watercourse 2).
3. Around the CPI centre site (Castlefinn Watercourse 1 and 2).
4. Around the two properties at risk to the south of the River Finn at Coolyslin (River Finn 1 and 2).
5. To the north of CPI centre along the Castlefinn Watercourse (Castlefinn Watercourse 1).

The model showed that direct defences would be technically viable in preventing flood waters from inundating Castlefinn from the River Finn. Direct defences around the CPI Centre site would protect the west of the town from the secondary flood mechanism arising from flood waters building up from the Castlefinn watercourse when it is 'locked out' from discharging to the River Finn. The direct defences would have to cross the Bridge Burn Stream and Castlefinn Watercourse. Culverts with flap valves would be required to allow these watercourses to continue to discharge into the River Finn but prevent the River Finn flood waters from backing up into Castlefinn, during flood events. Flood waters would therefore still build-up on the defended side of these embankments.

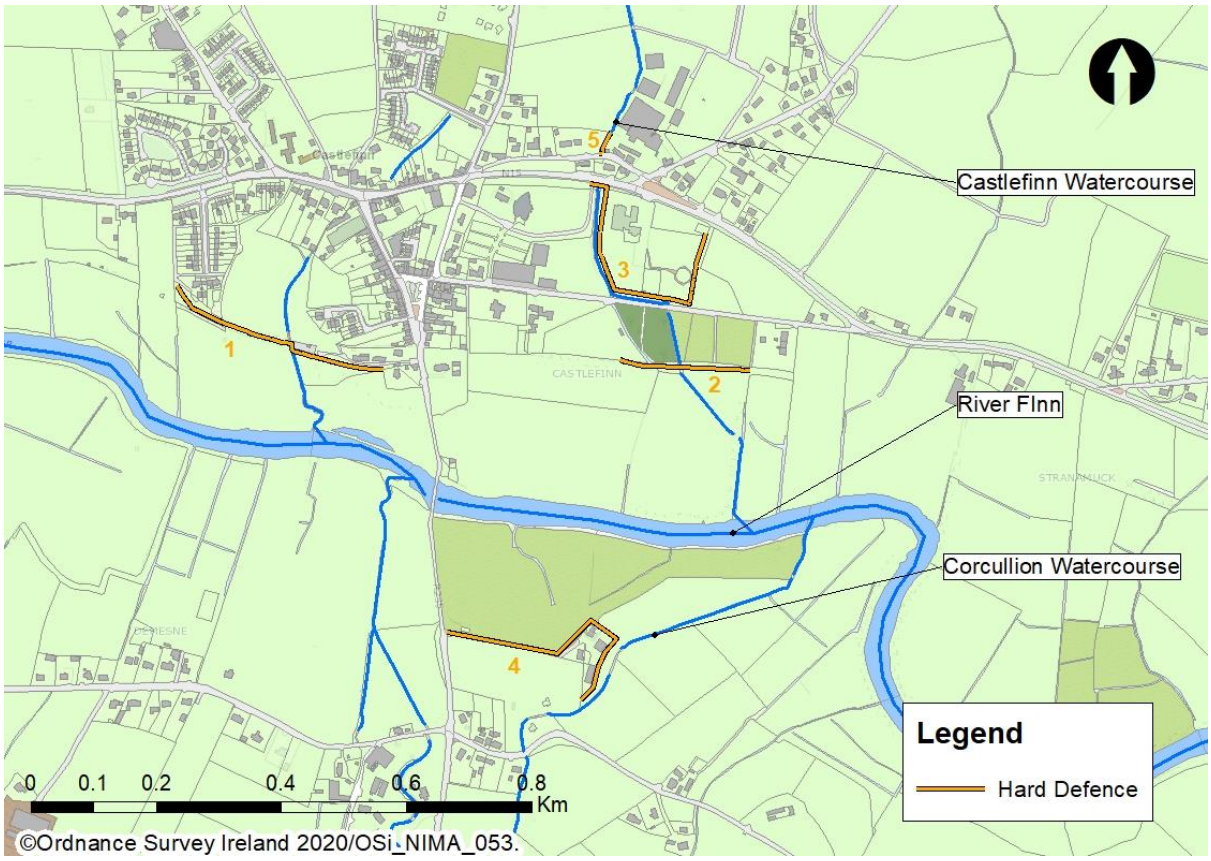


Figure 3.3 Location of Hard Defences

3.1.5 Increased Conveyance

Increased conveyance was considered for the Bridge Burn and Castlefinn Watercourse. Increasing the conveyance of the River Finn would not address Flood Mechanism Finn 2 (backwater from the Foyle) and was therefore screened out.

The only applicable increased conveyance measure identified was culvert upgrading to address the constrictions causing flooding on both watercourses. A new 1200mm diameter culvert on the Bridge Burn Stream and a 1350mm diameter culvert on the Castlefinn watercourse were modelled in combination with the Walls and Embankments measure (3.1.4), which was found to be the only

technically viable measure to prevent backwater from the Finn coming up these watercourses. The results showed that there would be no out-of-bank flooding on the two tributary watercourses.

Increased conveyance (culvert upgrade) is a viable measure for the Bridge Burn and Castlefinn Watercourse when used in combination with Walls and Embankments.

4 OPTION DEVELOPMENT

Following the Screening of Measures, a shortlist of measures was identified to address the flooding mechanisms in Castlefinn from the River Finn, Bridge Burn Stream and Castlefinn Watercourse. These measures are summarised in Table 4.1 below.

Table 4.1 Short list of measures

Measure	River Finn	Bridge Burn	Castlefinn Watercourse
Relocate/Reconstruct properties	✓[1]	✗	✗
Divert river	✗	✗	✗
Flood bypass channel	✗	✗	✗
Upstream flood storage	✗	✗	✓[3]
Walls & Embankments	✓	✓[2]	✓[2]
Increase conveyance	✗	✓[3]	✓[3]
Sediment deposition and traps	✗	✗	✗
Tidal barrage	✗	✗	✗

Notes:

[1] Relocation of properties is only applicable to the isolated properties at Coolyslin, to the south of the River Finn

[2] Walls and embankments can only prevent flooding on the Bridge Burn when used in combination with increased conveyance (culvert upgrade). Walls and Embankments can only prevent flooding on the Castlefinn Watercourse when used in combination with either increased conveyance (culvert upgrade) or upstream storage.

[3] Increased conveyance (culvert upgrade) can only prevent flooding on the Bridge Burn and Castlefinn Watercourse if used in combination with Walls and Embankments.

The shortlisted measures were considered in the development of options. Options were developed to provide the required SoP (1% AEP) from all flooding mechanisms.

4.1 Properties at Risk at Coolyslin

The two properties at risk in Coolyslin to the south of the River Finn were considered in isolation to minimise unnecessary combinations of options to be assessed for the scheme. This was considered appropriate given the impact of measures in this area would have no bearing on measures elsewhere.

The first viable measure is the relocation of both properties out of the floodplain. This would involve purchasing the properties. One property is a residential bungalow and the other is a farm shed / warehouse.

The second viable measure is the protection of the properties with direct defences. This would involve raising the access road (190m) into the properties off the R235 and protecting them with a reinforced concrete flood wall (230m) partially surrounding the properties to tie into high ground to the south.

Whole Life Costing was carried out for the two viable measures at this location based on preliminaries, fees, operation & maintenance, and other additions that would be considered for a scheme. An

appraisal of the economic analysis, as well as technical, environmental and social considerations for the viable measures at Coolyslin, is summarised in Table 4.2.

Table 4.2 Appraisal of Measures at Coolyslin

Criteria		Coolyslin Properties - Walls and Road Raise	Coolyslin Properties - Relocation	Preferred Measure
Technical				
Standard of Protection	Flood Risk Management measures may have a level of residual (remaining) risk.	1% AEP – residual risk	No residual risk as properties removed from the floodplain	Relocation
Adaptation	How easily adaptable are the measures to climate and other future changes which could increase flood risk.	Adaptable at moderate cost – walls and roads could be raised at moderate cost at a later date.	No adaptation required.	Relocation
Economic				
Whole Life Cost	Includes the following percentages on construction costs: Preliminaries - 15% Ground Investigation – 5% Design & Supervision – 16.6% Archaeology & Environmental Mitigation – 10% Optimism Bias – 49%	€ 1,390,903	€ 692,384	Relocation
Social				
Impact on people	Measures will have different social impacts on the owners / residents of the properties.	Some residual risk would remain where rapid inundation of the properties could occur if defences are overtopped. This may be a concern for residents.	Detachment of small settlement cluster. Detachment from neighbouring properties (residential) and surrounding grazing land (agricultural).	Equal
Visual Impact		Access road elevated above existing ground by more than 2m in places. Properties surrounded by a wall typically 1.9m high.	Removal of two buildings from lower Finn Valley but replaced elsewhere.	Relocation
Environmental				
WFD objectives	Potential water quality Impact on Finn. Construction adjacent to Corcullion watercourse could provide a pathway to the River Finn for pollution.	Construction works - Higher potential impact	Demolition & Reinstatement - Lower potential impact.	Relocation

Criteria		Coolyslin Properties - Walls and Road Raise	Coolyslin Properties - Relocation	Preferred Measure
Ecological impact	Potential impact on local ecology which includes bats, badgers, otters and fisheries.	Larger construction site and duration. Construction of reinforced concrete wall adjacent to watercourse.	Lower impact from demolition works which will be smaller in footprint and duration.	Relocation
Landscape impact	Measures will be located in the lower extents of the Finn Valley Landscape Character Area (LCA) where the scenic amenity is classified as moderate.	Increased	Reduced by the removal of buildings from the LCA.	Relocation

The appraisal of potential measures for the properties at Coolyslin found that relocation is preferable across almost the entire range of criteria. Relocation was taken forward as the preferred measure to be included in all the options.

4.2 Potential flood defence routes (Walls and Embankments)

When developing options with direct defences on the River Finn, the interaction with the Bridge Burn and Castlefinn Watercourse needs to be considered. The line of the defence will determine the storage capacity behind the defence to store flood waters from the tributaries while the River Finn is in flood.

The potential River Finn defence line intersecting the Bridge Burn in the west of the town is fixed somewhat by the location of the WwTP sited on the old railway line. The flood defence line is required to travel south of the WwTP before tying into high ground. This arrangement was modelled, and the results showed that the low lying land behind the flood defence would provide enough capacity to store the flood water from the 1% AEP event in the Bridge Burn. To the west of the town a second defence line was considered whereby the defence would go around the WwTP and then form a longer horseshoe line along the boundary of properties and the agricultural land at Grahamsland. This line would be desirable in that it would retain more of the Finn floodplain and the defences would be lower in height as they would be located further up the floodplain. However, this line of defence would provide no storage for floodwaters emanating from the Bridge Burn catchment. Flows coming down the Bridge Burn culvert could not be discharged leading to residual flooding through the drainage system to the N15 road junction at McGlynns. For this reason, this defence line was deemed not technically viable.

An existing defence line (the recently constructed CPI defence) intersects the Castlefinn Watercourse and is located along the old railway line in the east of the town. Modelling of this defence line showed that the land behind the flood defence would not have enough capacity to store flood water from the Castlefinn Watercourse. For this defence line to be considered, a secondary defence line is required around the CPI Centre site and adjacent to the farmyard upstream of the N15 to prevent floodwater from backing up from the Castlefinn Watercourse when it is locked out from the River Finn due to high

water levels. The existing CPI defence would need to be reconstructed to provide the target Standard of Protection.

Alternatively, a single line of defence around the CPI Centre site could protect the eastern portion of Castlefinn at risk from both the River Finn and Castlefinn Watercourse. This defence would be much higher at an average of 2.5m above ground than a defence around the CPI Centre site, designed for the secondary risk arising from the Castlefinn Watercourse, at an average of 1.2m.

Raising or defending Chapel / Hollow Road was considered but was ruled out based on technical and economic grounds. At its lowest point, where it bridges the Castlefinn watercourse, the road would need to be elevated by up to 3.5m. The footprint of the embankment structure required to elevate the road would cover the Castlefinn watercourse as it runs along the south of the CPI site. For this to be the line of defence from the River Finn (abandoning the existing CPI defence line further south) the Castlefinn watercourse would need to be culverted in its entirety from Chapel / Hollow Road to upstream of the N15. Manholes would need to be sealed along the culvert route to ensure the Castlefinn watercourse continues to drain without flooding the CPI site. Local stakeholders provided a negative response to such a solution during the Opening Public Consultation.

A defence line at the existing location to the south of Chapel / Hollow Road will provide protection to the road. It would continue to flood, albeit less frequently and to a lower depth, when the Castlefinn watercourse is backed up during times of flooding in the Finn. The damage assessment does not assign a monetary damage or benefit to Chapel / Hollow Road. If defences against the River Finn are in place and effective there is a short, local diversion available for properties accessed from Chapel / Hollow Road.

4.3 Proposed Options

To address the flooding mechanism on the River Finn, walls and embankments must form part of any option.

To address the flood mechanisms on the Castlefinn Watercourse and the Bridge Burn upgrading the culverts under the N15 must form part of any option. Although the Bridge Burn culvert is in a much worse condition than the Castlefinn Watercourse culvert, neither can be relied upon to provide the required Standard of protection across the design life of a scheme. The upgrades required to the Castlefinn Watercourse are dependent on the flood flows in the Castlefinn Watercourse. When combined with upstream storage the capacity requirements are reduced and portions of the culvert in good condition can be retained.

To address flooding at Coolyslin it has been determined that property relocation must form part of any option (see 4.1).

Variation in the options is therefore limited to the measures to address flooding in the eastern portion of Castlefinn. These can be one of the following:

- Reconstruction of the CPI defence to protect against flooding from the River Finn, a full upgrade of the Castlefinn Watercourse culvert under the N15 to a new 1350mm diameter culvert and secondary defences around the CPI Centre and at the farmyard upstream of N15.
- Reconstruction of the CPI defence to protect against flooding from the River Finn, partial upgrade of the Castlefinn Watercourse culvert under the N15 (900mm diameter culvert) and storage areas upstream and adjacent to the CPI Centre.
- Abandonment of CPI defence and a new flood wall constructed around the CPI Centre site and farmyard upstream of the N15 to protect against flooding from the River Finn and Castlefinn Watercourse. Full upgrade of the Castlefinn Watercourse culvert under the N15 to a new 1350mm diameter culvert.

A summary of the potential options is provided in Table 4.3.

Table 4.3 Potential Options

Location	Option 1	Option 2	Option 3
River Finn (West)	Flood Embankment	Flood Embankment	Flood Embankment
River Finn (East)	Flood Embankment	Flood Embankment	Piled Flood Wall[1]
River Finn (Coolyslin)	Property Relocation	Property Relocation	Property Relocation
Bridge Burn	New Culvert	New Culvert	New Culvert
Castlefinn Watercourse	New Culvert	Partial Culvert Upgrade	New Culvert
	Walls and Embankments	Upstream Storage	Piled Flood Wall[1]

Note1: The piled flood wall around the CPI site will protect from both the River Finn and Castlefinn Watercourse flood mechanisms.

The options are described in greater detail in the following sections.

4.3.1 Option 1

Option 1 consists of a total of 985m of flood embankment in three locations to protect from flood waters from the River Finn; intersecting the Bridge Burn (375m) in the west of Castlefinn, intersecting the Castlefinn Watercourse (210m) in the east of Castlefinn, and surrounding the CPI centre (400m). Embankment heights are on average 1.15m high at the CPI Centre rising to over 5m for portions of the Finn embankments in the east and west of the town. Watercourse culverts will be constructed through the Finn embankments to convey the Bridge Burn and Castlefinn Watercourse through the embankments. The downstream headwalls will be fitted with non-return (flapped) outfalls. 62m of reinforced concrete flood walls are proposed in areas where an embankment cannot be accommodated

due to existing constraints. These will be at the CPI Centre and adjacent to the farmyard upstream of the N15 on the Castlefinn Watercourse. These walls will be on average 0.95m in height.

It is proposed to abandon the existing culvert on the Bridge Burn and build an entirely new 1200mm diameter culvert along a new route 190m in length. The existing route passes under or very close to existing houses and the new route will avoid this by going through the access road into the Nena Models factory. It is proposed to reconstruct the 55m long Castlefinn Watercourse culvert under the N15. The new culvert will be 1350mm in diameter.

Property relocation is proposed for two properties south of the River Finn at Coolyslin.

Figure 4.1 shows Option 1. The heights of defences above ground are noted at selected locations.

Figure 4.1 Option 1

4.3.2 Option 2

Option 2 consists of a total of 585m of flood embankment in three locations to protect from flood waters from the River Finn; intersecting the Bridge Burn (375m) in the west of Castlefinn and intersecting the Castlefinn Watercourse (210m) in the east of Castlefinn. Embankment heights are on average 3.43m and over 5m in places. Watercourse culverts will be constructed through the Finn embankments to convey the Bridge Burn and Castlefinn Watercourse through the embankments. The downstream headwalls will be fitted with non-return (flapped) outfalls.

It is proposed to abandon the existing culvert on the Bridge Burn and build an entirely new 1200mm diameter culvert along a new route 190m in length as in Option 1. It is proposed to reconstruct portions of the 55m long Castlefinn Watercourse culvert under the N15. It is estimated that approximately 30m of the culvert will need to be replaced with 900mm diameter tying into the existing sections assessed as being suitable to be retained.

Option 2 proposes to create two flood storage areas. This includes 46,600m^3 of flood storage upstream of Castlefinn on the Castlefinn Watercourse. A 2.06m flood embankment will retain flood waters in a topographical depression adjacent to a farm in the middle catchment to the northeast of Castlefinn. A 1m x 1.5m box culvert and an overtopping weir will provide the flow control to attenuate flows. An additional storage area is proposed to the east of the CPI Centre with an effective storage volume of 4,140m^3. This maximises storage in an area which is subject to flooding currently and does not require flow attenuation structures. It would be created by excavating approximately 8,500m^3 of material.

Property relocation is proposed for two properties south of the River Finn at Coolyslin.

Option 2 is shown in Figure 4.2.

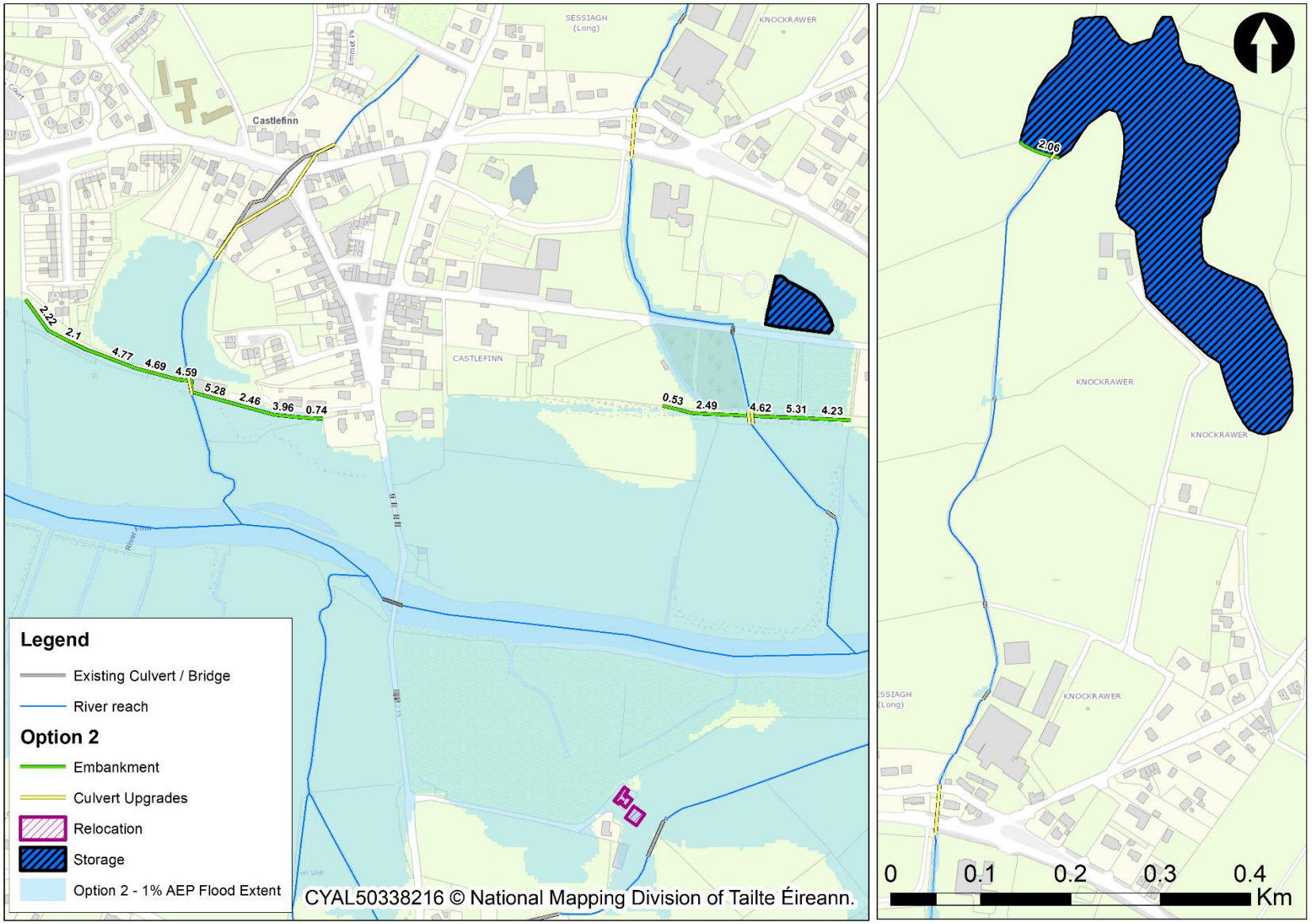


Figure 4.2 Option 2

4.3.3 Option 3

Option 3 consists of a flood embankment to protect from flood waters from the River Finn; intersecting the Bridge Burn (375m) in the west of Castlefinn. Embankment heights are on average 3.45m rising to over 5m for portions of the Finn embankment. A watercourse culvert will be constructed through the Finn embankment to convey the Bridge Burn through the embankment. The downstream headwall will be fitted with a non-return (flapped) outfall.

At the CPI Centre site and upstream of the N15 adjacent to the farmyard a flood wall and portions of embankment will protect the eastern portion of Castlefinn from the River Finn and the Castlefinn Watercourse. This will include 382m of reinforced concrete flood wall supported on sheet pile foundations. These sections will be on average 2.01m high and up to 2.36m in places. As the wall returns along the eastern boundary of the site the wall construction will transition to 40m of reinforced concrete foundation where it is not bordering the Castlefinn Watercourse. These sections will range from 1.66m to 2.04m in height. Further north this will transition to 54m of earthen embankment ranging from 1.26m in height before transitioning to meet existing high ground.

It is proposed to abandon the existing culvert on the Bridge Burn and build an entirely new 1200mm diameter culvert along a new route 190m in length as in Option 1 and 2. It is proposed to reconstruct the 55m long Castlefinn Watercourse culvert under the N15 as in Option 1. The new culvert will be 1350mm diameter.

Property relocation is proposed for two houses south of the River Finn, in the Finn floodplain.

Option 3 is shown in Figure 4.3.

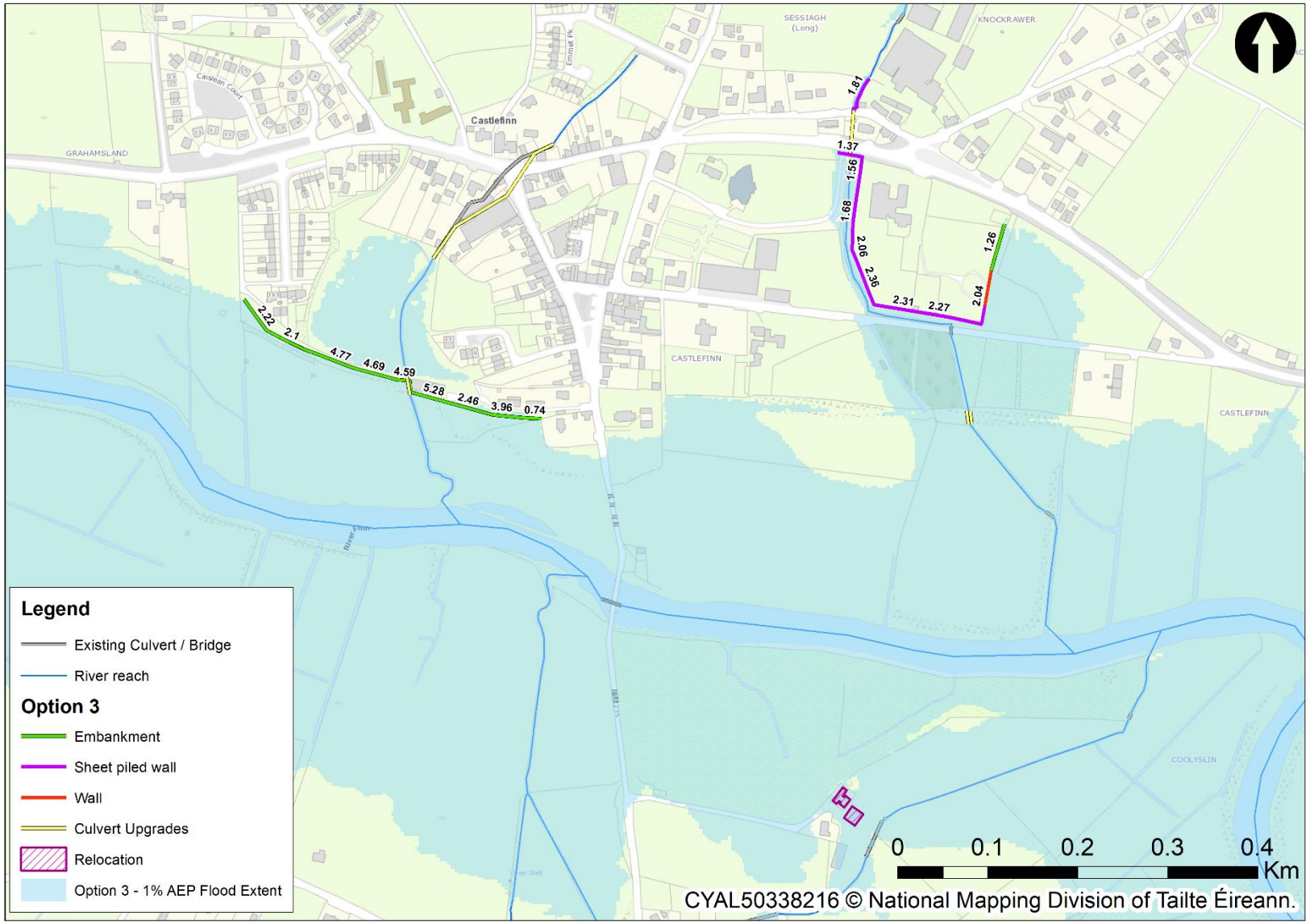


Figure 4.3 Option 3

4.4 Ancillary works

The only ancillary works required for the Castlefinn Options are standard requirements such as back drainage and the fitting of non-return (or flapped) outlets to drainage outfalls where they pass under flood defences. Back drainage may be needed on the embankments where there is potential for the embankment to trap water. It may be desirable in other locations to forego back drainage to encourage wetland conditions (i.e. between the embankment and Hollow Road).

Back drainage to the CPI and farmyard defences will take the form of filter drains with non-return outfalls through the walls and embankments. Design of these drainage systems must consider the potential for lock-out due to high water levels in the watercourse and design for exceedance.

4.5 Freeboard Assessment

A freeboard assessment was required for each option in order to determine a suitable freeboard for each reach of flood defence. The freeboard assessment was based upon the sensitivity analysis as detailed in Section 3.6 of the Castlefinn FRS Hydraulics Report[7]. The sensitivity analysis considered various parameters to which the hydraulic model may be sensitive to, such as changes to roughness, headloss across structures, increased flows, 2D zone cell size, joint probability, and blockages. The sensitivity analysis identified increased flows as the parameter the model was most sensitive to. This parameter change was applied to the model with the options in place to assess the impact on the defences.

The percentage increase in flow was determined through a hydrological analysis and is detailed in Chapter 5 of the Castlefinn FRS Hydrology Report[8]. The analysis determined that there was a moderate to high degree of uncertainty in the hydrological estimates, particularly across the tributaries of the River Finn. The uncertainty on the River Finn was assessed to be lower given the presence of gauging stations to anchor the hydrological estimates to. A suitable uncertainty factor was applied to the design flows to capture an upper bound for the design flood event flows on the River Finn and its tributaries. For the 1% AEP Flood Event, a percentage increase of 17% was applied to the upstream inflow to the River Finn and 37% was applied to the lateral inflows. A 57% increase was applied to the tributaries.

A hydraulic model simulation was run for each option with the increased flows.

The freeboard assessment resulted in increases to the different measures proposed within options 1 to 3. Note that the options as described in Section 4.3 include the allowances for increased freeboard described in the following sections.

[7] Castlefinn Flood Relief Scheme Hydraulics Report IBE1760 Rp015

[8] Castlefinn Flood Relief Scheme Hydrology Report IBE1760 Rp019

In general, a higher freeboard is required than the standard heights used in Ireland (300mm for flood walls and 500mm for embankments). The additional 200mm for embankments is an allowance for settlement following construction and through the design life.

4.5.1 Finn Flood Embankments (Options 1, 2 and 3)

The increases in flow on the River Finn resulted in an increase of 360mm in peak water levels. The freeboard required on these embankments was therefore increased from 500mm to 560mm.

4.5.2 CPI Centre walls and Embankments (Option 1)

The increases in flow and hydrograph volume of 57% resulted in increases of 540mm in peak water levels. The freeboard required on embankments was therefore increased from 500mm to 740mm. The freeboard required on walls was increased from 300mm to 540mm.

4.5.3 CPI Centre Walls and Embankments (Option 3)

The increases in flow on the River Finn combined with the increases in flow on the Castlefinn Watercourse resulted in an increase of 390mm in peak water levels. The freeboard required on embankments was therefore increased from 500mm to 590mm. The freeboard required on walls was increased from 300mm to 390mm.

4.5.4 Culverts (Options 1, 2 and 3)

The Bridge Burn culvert was initially found to be suitable to convey flows without flooding at a diameter of 900mm. This was required to be increased to 1200mm following hydraulic modelling of the sensitivity flows.

The Castlefinn Watercourse culvert was initially found to be suitable to convey flows without flooding at a diameter of 1050mm. This was required to be increased to 1350mm following hydraulic modelling of the sensitivity flows.

4.5.5 Storage Areas

The upper storage area on the Castlefinn Watercourse was initially sized at 29,683m^3. This was increased to 46,600m^3 following the freeboard assessment. The controlling weir was increased in height from 1.56m to 2.06m to achieve the additional storage volume. The outlet culvert was unchanged to retain the same restriction to flow to prevent flooding downstream.

The lower storage area adjacent to the CPI Centre initially required 5,425m^3 of excavation to achieve additional storage to prevent floodwaters from entering the CPI Centre site. This was increased to 8,500m^3 following freeboard assessment to accommodate the additional flood volume.

5 OPTION APPRAISAL

In appraising the proposed options, the aim is to identify the preferred option based on technical, economic, social, and environmental criteria. The options appraisal consists of a Multi-Criteria Analysis (MCA) and a Cost Benefit Analysis (CBA). Both analyses were used in identifying the preferred option and are detailed in the sections below.

5.1 Multi Criteria Analysis

The MCA considered four criteria, technical, social, economic, and environmental and the method used followed 2018 OPW guidance[9]. Each criterion was given equal weighting so that no one criterion was given greater influence in appraising options. Each criterion considered several aspects of the option and are summarised in Table 5.1.

Table 5.1 MCA Criteria

Criteria	Objective	Description
Technical	1a	Ensure flood risk management options are operationally robust
	1b	Minimise health and safety risks in construction, maintenance, and operation of the flood risk management option
	1c	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change
Economic	2a	Reduce economic damages
	2b	Minimise risk to transport infrastructure
	2c	Minimise risk to utility infrastructure
	2d	Manage risk to agriculture
Social	3a (i)	Minimise risk to human health and life - Residents
	3a (ii)	Minimise risk to human health and life - High vulnerability properties
	3b (i)	Minimise risk to community - Social Infrastructure and Amenities
	3b (ii)	Minimise risk to community - Local Employment
Environmental	4a	Support the objectives of the WFD
	4b	Support the objectives of the Habitats and Birds Directives
	4c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment
	4d	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)
	4e	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence
	4f (i)	Avoid damage to or loss of features, institutions and collections of **architectural** cultural heritage importance and their setting and improve their protection from extreme floods.
	4f (ii)	Avoid damage to or loss of features, institutions and collections of **archaeological** cultural heritage importance and their setting and improve their protection from extreme floods.

[9] The OPW technical methodology note – Option Appraisal and the Multi-Criteria Analysis (MCA) Framework (Version Rev. B, September 2018)

Using OPW guidance and professional judgement the benefits and impacts of each option were scored. A total MCA score was calculated for each option and is presented in Table 5.2.

Table 5.2 MCA Scoring

Option No.	Technical Score	Social Score	Economic Score	Environmental Score	Total Score
Option 1	900	974	875	-94	2656
Option 2	800	974	781	-54	2501
Option 3	900	974	867	-158	2583

Options 1 and 3 scored slightly higher against technical criteria. All options include flood walls and/or embankments and culvert upgrades. The nature of these defences means each option will require in-channel working, utility services modifications, traffic management and landowner engagement/liaison. Options 1 and 3 scored slightly better than Option 2 due to uncertainty around the adaptability of the storage measures in Option 2.

Socially, all options scored the same. All of the options provide the same levels of protection to all of the social properties in Castlefinn.

Economically Option 1 scored the highest. Option 2 scored lowest on account of the agricultural land upstream which would be made less productive due to its use as a flood storage area. Option 3 scored slightly lower than Option 1 as it affords less protection to Hollow Road by the fact the Finn defence line is set back at the CPI Centre.

Environmentally all options scored similarly due to potential impacts on the River Finn SAC which is hydrologically connected to the works area. Option 2 scored marginally better due to the lesser embankment works and the lower potential to impact downstream habitats. Option 3 scored worst due to the height of the walls required around the CPI Centre and the potential visual and landscape character impact this could have on the town.

Details of the MCA for each option are provided in Appendix D.

5.2 Cost Benefit Analysis

The CBA considers the whole life cost of each option over a 50-year life span and compares this cost with the expected benefit of flood damage avoided over the same 50 years. This analysis is summarised in the Benefit Cost Ratio (BCR) and presented in Table 5.3. A detailed breakdown of the costing of options is provided in Appendix E.

Table 5.3 Cost of Options

Option No.	Basic Construction Cost	Total Cost[1] exc. Optimism Bias	Optimism Bias	Total Cost inc. Optimism Bias	Benefit from damage avoided	BCR
Option 1	€3,390,181	€4,403,218	49%	€6,678,400	€6,108,654	0.91
Option 2	€3,587,963	€4,642,268	53%	€7,139,274	€6,108,654	0.86
Option 3	€4,185,918	€5,391,181	49%	€8,184,442	€6,108,654	0.75

1 Total costs include preliminary costs, ground investigations, design and environmental fees, site supervision fees, archaeology and environmental mitigation, art, and operation and maintenance.

With all options providing the same SoP the damage avoided and therefore the monetary benefit for all options is the same. The cost of the option is therefore the differential factor within the CBA. Option 1 is the cheapest solution and provides the highest BCR.

When combining the MCA scores with the CBA an MCA benefit-cost ratio score can be calculated to give an overall score. This score considers the social, economic, and environmental MCA scores against the cost of the option. Option 1 was identified as having the most positive score.

Table 5.4 MCA Scoring

Option No.	Cost	MCA benefit-cost	BCR
Option 1	€6,678,400	262.88	0.915
Option 2	€7,139,274	238.29	0.856
Option 3	€8,184,442	205.69	0.746

5.3 Carbon Costing

The carbon cost for each of the options in terms of both the total tonnes of Carbon Dioxide equivalent (tCO_{2e}) the options will produce and the financial cost of this quantity of CO_{2e} has been calculated. Carbon cost calculations considered the quantities of materials used including the sourcing and production of these materials, the quantity of CO_{2e} generated in the construction process and the quantity of CO_{2e} generated per year in operation and maintenance. Table 5.5 summarises the carbon cost of each option which includes the estimated carbon cost associated with the relocation of a residential property in each of the three options.

Table 5.5 Cost of Options

Activity	Option 1	Option 2	Option 3
Total (tCO_{2e})	2716	2333	3681
Estimated price of carbon of option	€867,789	€745,344	€1,175,816

The quantities of the total carbon emissions generated between Option 1 and 2 and the carbon costs associated with each are relatively similar. The slight carbon benefit that is shown for Option 2 is the lower scale of works on the Castlefinn Watercourse with the creation of two storage areas which require less carbon-intensive processes and use of materials than Option 1. Option 3 has a larger quantity of carbon generated. This is because Option 3 requires the construction of a significant flood wall that is sheet-piled which results in greater carbon-emitting materials and total carbon emissions of the option. Details of the carbon costing are provided in Appendix F.

6 PREFERRED OPTION

The screening of measures and option development identified three options that would effectively alleviate the risk of flooding to the community of Castlefinn to the design SoP of a 1%AEP flood event.

The Multi-Criteria Analysis (MCA) which considers technical, social, economic, and environmental criteria, identified Option 1 as having the highest MCA score. Similarly, the Cost Benefit Analysis identified Option 1 as having the highest BCR. From these analyses, Option 1 is the best value for money and provides the most positive benefits to the community of Castlefinn. The carbon costing assessment identified Option 2 as having a lower carbon cost than Option 1 with Option 3 generating considerably more carbon.

Overall Option 1 provides the most sustainable solution to managing flood risk in Castlefinn. It is the best value for money and scores highest against a range of social, technical and economic criteria. The proposed layout of the preferred option along with the heights of the defences is provided in Appendix G.

The following sections consider additional aspects of the preferred option.

6.1 Nature-based Solutions

A Nature-based Solutions for Catchment Management (NbS-CM) feasibility assessment was carried out as part of the Castlefinn Flood Relief Scheme[10]. The assessment found that although there was good potential to implement NbS-CM within parts of the Study Area, there was moderate to low potential for NbS-CM to reduce flood risk. The most potential to implement NbS-CM was assessed to be in the upper River Finn catchment and the potential in the Bridge Burn and Castlefinn Watercourse sub-catchments was deemed to be low.

Implementing NbS-CM measures across a large area can be complex. Costs, funding, and land use constraints can limit the extent of NbS-CM. It is unlikely that all the NbS-CM measures would be implemented in one go and a phased approach would be more realistic.

Measures and locations best suited to impact and complement the flood scheme in Castlefinn were considered. Measures local to Castlefinn would have the greatest influence and would therefore be more desirable to consider within the scheme. As such the River Finn tributaries flowing through Castlefinn were considered and the reach of the River Finn up to Castlefinn. Measures include significant areas of woodland creation, located within floodplains and riparian corridors and in less productive land that could potentially be converted to woodland. These woodlands would help regulate flood flows, sequester carbon, create new habitats, and provide potential for creating amenity areas linking Castlefinn and Stranorlar. Other measures fall within this area of interest including land management measures, such as buffer strips and hedgerows, ponds, and swales.

[10] Castlefinn FRS – NbS-CM Feasibility Report IBE1760

The area west of Ballybofey-Stranorlar was identified in the Catchment Characterisation as being an area of good NbS-CM potential, primarily run-off reduction measures. This area is mainly blanket bog with significant areas showing signs of degradation. The ground is steep with high rainfall and is considered an area of high flow generation and erosion. Outside of the Flood Scheme environs, the area of the Blue Stack Mountains could be considered as a discreet area for NbS-CM.

In summary the NbS-CM feasibility assessment found that the most NbS-CM potential was in the upper catchment of the River Finn. As discussed in Chapter 3 measures which reduce the flood flows and volumes on the River Finn do not achieve the required Standard of Protection due to the backwater flood mechanism (River Finn 2) discussed in section 2.1.1. NbS-CM may be considered effective measures in the context of achieving wider catchment objectives within the Study Area but are not considered further to achieve FRM objectives in isolation and will not form part of the scheme.

6.2 Quick Wins

Quick wins consist of works that can be carried out in the near future at minimal cost. Within the preferred option, the property relocation measure is a part of the FRS which could be accelerated ahead of the main FRS construction works package.

Planning permission for the entire scheme will likely be required to progress this element. It is envisaged that the preparation of documents could commence before receipt of planning such that the measure could be implemented at the start of Stage III of the scheme.

6.3 Public Realm and Environment Opportunities

Through consultation with project stakeholders the following potential opportunities for the scheme to enhance the public realm have been identified.

1. The proposed flood defence embankment along the line of old railway embankment to the south of Castlefinn represent an opportunity to develop a community path or greenway at the crest, providing views out over the Finn Valley and back towards the town itself. The two embankment greenways could be joined via continuation of both greenways towards the R235 and accessed from the R235.
2. The North West Greenway Lifford to Castlefinn section has been submitted for planning at the time of writing. The route of this scheme runs adjacent to the N15 from the centre of Lifford to the centre of Castlefinn. If the proposals in (1) above were adopted both routes could be connected via Hollow Road and an access route connecting Hollow Road to the embankment south of the CPI centre.
3. The area between the proposed flood defence embankment to the south of the CPI Centre and Hollow Road is already a local nature reserve with amenity value. Development of the proposed flood defence embankment could provide access to this area, potentially in combination with (1) and (2) above.
4. The area to the north of the proposed flood defence embankment to the south of Grahamsland is to be retained as flood storage. To secure this flood storage function the area could be developed as parkland. Development of the proposed flood defence embankment could provide access to this area, potentially in combination with (1) and (2) above.

6.4 Climate Change Adaptation Plan

The preferred option was considered for climate change adaptation. Recommendations for adaptation to the preferred option can be found in the Castlefinn FRS Climate Change Adaptation Plan (CCAP). The scheme CCAP includes measures which must be included in the initial scheme to ensure it is adaptable. These include:

- Amendment of the preferred form of defence along the car park at the western side of the CPI Centre. 96m of embankment with an average height of 0.95m is to be replaced by a reinforced concrete floodwall with an average height of 0.75m.
- Amendment of the preferred new culvert (192m) for the Bridge Burn from a 1200mm diameter circular culvert to either a 1350mm circular culvert or 1m x 2m box culvert such that it can convey flows up to the HEFS SoP.
- Additional land within the CPI Centre of 1,023m2 to facilitate future expansion / extension of earthen flood embankments.
- Additional land for the River Finn flood embankments of 6,013m2 to facilitate future expansion / extension of earthen flood embankments.

7 CONCLUSIONS

The objective of the Castlefinn FRS Scheme Analysis and Development was to identify options for Castlefinn that are economically viable, and environmentally acceptable while also being acceptable to the community and other stakeholders. Options must be effective in protecting the areas at flood risk within the community of Castlefinn against flooding to the defined SoP of a 1%AEP flood event.

The majority of the flood risk to the community of Castlefinn emanates from the River Finn and the backwater effect that causes flooding of two tributaries, the Bridge Burn and Castlefinn Watercourse, as water levels in the River Finn rise. Flooding in the 1% AEP flood event produces flood risk to 17 residential properties and 16 commercial properties. The N15 road through the town is also impacted by flooding.

Three options were developed that met the objectives of the FRS. All options require hard defences (walls or embankments) to protect from the main source of flood risk; the River Finn. All options require upgrades to existing culverts which cannot currently be relied upon to convey flows throughout the design life of the scheme. All options include the relocation of two properties to the south of the River Finn at Coolyslin.

Variation in the options is in how the flood risk is managed to the east of the town, along the Castlefinn Watercourse. Option 1 includes an embankment protecting from the River Finn and further walls and embankments around the CPI Centre site to protect from the secondary risk of flooding from the Castlefinn Watercourse, at times when it is prevented from discharging by high water levels in the Finn. Option 2 includes the same embankment protecting from the Finn but the risk from the Castlefinn Watercourse is managed through upstream storage. Option 3 includes one single flood defence line around the CPI Centre site to protect from both the Finn and Castleifnn Watercourse. This flood defence would mainly be in the form of a wall over 2m in height.

A freeboard assessment determined increased design requirements for flood defences above the minimum allowances. The increase is highest on the tributary watercourses where the uncertainty in the analysis is highest.

An appraisal of the options was carried out using Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA). The MCA considered the technical, social, economic, and environmental benefits and impacts of each option to the community in Castlefinn. Option 1 scored the highest in the MCA. The CBA calculated the whole life cost of each option over a 50-year period and compared this with the benefit of flood damage avoided. Benefit-Cost Ratios (BCR) were produced for each option. Option 1 was identified as having the highest BCR.

All options achieve the objective to provide the design SoP. The objective to provide an economically viable, environmentally acceptable, and acceptable solution to the community and other stakeholders is achieved best through Option 1. Option 1 is therefore recommended as the preferred option.

Appendix A

Damage assessment methodology

A.1 DAMAGE ASSESSMENT GUIDELINES – REPUBLIC OF IRELAND

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

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

The MCM is a result of research carried out by Middlesex University Flood Hazard Research Centre and provides data and techniques for assessing the benefits of flood risk management in the form of flood alleviation. The MCM has focused on the benefits that arise from protecting residential property, commercial property, and road disruption amongst other areas as experience has shown that these sectors constitute the vast majority of the potential benefits of capital investment.

Based on this research the MCM provides depth damage data for both residential and commercial properties. For certain depths of flood water, a monetary damage has been assigned to a property. This damage is a combination of the likely items within the building and the building structure itself. The damage to each property is dependent on the property type; as such the MCM has categorised both the residential and commercial properties. An example of depth damage data for residential properties is shown in Figure A.1. Property damages are available for a number of different flood sources, including fluvial, coastal surge and wave overtopping. The appropriate datasets are sourced for the applicable flood mechanism/s which is assessed for the subject area.

RPS also employs OPW economic appraisal guidance (Technical Methodology Note - Cost-Benefit Analysis (CBA), Sept 2018) produced for the National CFRAM Programme, which provides specific rules relating to intangible damages, property capping, and calculation of benefits associated with implementation of flood alleviation options. Adoption of OPW guidance is discussed in later sections where relevant.

Any specific considerations outside what has been provided in this report will be included within the body of the main report.

Long Duration Major Flood Storm No Warning (2022-2023 Price base)

MCM Direct damage data (£). Depth in metres (m) - Initial Appraisal

Property-Type	mcm_code	property_type_age	-0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
Detached	111	pre-1919 Detached	5,215	10,571	40,679	58,808	78,706	93,703	104,076	108,354	115,111	126,048	135,687	148,843	156,683	167,064	179,255
	112	1919-1944 Detached	3,447	5,367	16,215	24,403	33,164	38,366	40,985	43,672	46,988	51,581	56,545	65,229	69,337	74,700	81,258
	113	1945-1964 Detached	3,263	5,685	18,757	28,250	37,364	42,329	44,964	47,578	50,749	55,084	59,444	68,746	73,239	78,980	86,346
	114	1965-1974 Detached	2,491	4,446	13,823	21,471	29,931	34,847	37,303	39,655	42,190	47,238	50,946	58,859	62,731	67,332	73,165
	115	1975-1985 Detached	2,435	4,394	15,185	23,597	33,802	40,480	44,423	47,278	49,384	54,631	58,902	67,252	70,074	73,345	77,817
	118	post-1985 Detached	2,372	4,365	15,524	24,541	34,863	42,842	47,160	50,308	52,318	58,176	63,139	72,126	74,603	77,635	81,684
Semi-detached	121	pre-1919 Semi-detached	3,954	4,970	13,056	19,233	25,825	30,301	32,643	34,203	36,145	40,584	43,942	50,223	52,935	56,814	61,757
	122	1919-1944 Semi-detached	4,153	5,783	14,914	21,751	28,062	31,856	33,719	35,472	37,849	41,816	44,753	52,341	55,487	59,524	64,264
	123	1945-1964 Semi-detached	4,153	5,783	15,054	21,717	28,106	31,948	33,615	35,445	37,534	41,860	44,800	51,746	54,893	58,930	63,669
	124	1965-1974 Semi-detached	2,073	3,387	10,882	16,566	22,679	27,106	29,517	31,840	34,515	39,166	42,656	49,623	53,674	59,448	65,435
	125	1975-1985 Semi-detached	2,124	3,171	10,824	17,462	24,373	28,933	31,398	33,255	34,690	38,576	40,907	46,300	48,294	50,652	53,368
	128	post-1985 Semi-detached	2,064	2,984	10,878	18,261	25,146	30,775	33,524	35,399	36,817	40,647	43,211	49,071	50,751	52,933	55,318
Terrace	131	pre-1919 Terrace	3,946	5,076	13,280	19,815	26,529	31,625	34,328	35,938	38,332	41,738	44,708	52,137	54,666	58,480	62,398
	132	1919-1944 Terrace	4,191	5,927	16,180	23,868	30,723	34,272	35,776	37,508	39,714	43,588	46,170	53,071	55,459	57,950	61,496
	133	1945-1964 Terrace	2,974	3,824	8,345	11,041	13,929	15,817	16,839	18,200	19,225	20,855	22,210	26,562	27,513	28,360	29,672
	134	1965-1974 Terrace	2,471	3,898	11,800	18,768	25,050	28,669	30,360	32,195	34,186	37,465	40,113	49,153	51,558	54,118	57,518
	135	1975-1985 Terrace	1,902	2,834	9,369	14,651	20,169	23,698	25,523	26,975	28,499	31,058	32,941	38,931	40,589	42,745	45,056
	138	post-1985 Terrace	1,833	2,587	9,559	15,569	21,135	25,995	27,941	29,419	30,667	33,351	35,414	41,301	42,617	44,602	46,571
Bungalow	141	pre-1919 Bungalow	4,125	5,551	16,033	23,681	31,695	37,348	40,458	42,302	44,002	47,724	50,270	57,366	59,706	62,367	65,644
	142	1919-1944 Bungalow	3,828	6,587	21,558	31,631	40,300	45,603	48,605	51,659	55,449	61,159	65,987	77,040	81,822	87,510	94,671
	143	1945-1964 Bungalow	3,956	6,023	19,097	28,978	37,354	41,864	44,318	47,083	50,026	56,129	61,935	72,811	78,073	84,310	93,631
	144	1965-1974 Bungalow	2,993	6,171	22,465	34,656	44,485	50,134	53,192	56,809	60,996	68,180	74,343	85,935	91,286	96,987	105,222
	145	1975-1985 Bungalow	2,780	4,875	18,476	29,445	39,770	46,295	50,679	54,058	56,979	63,593	68,441	78,451	81,536	84,344	88,468
	148	post-1985 Bungalow	2,656	4,388	19,012	31,664	42,094	51,582	56,338	59,836	62,176	69,116	74,434	84,282	86,627	89,068	92,425
Flat	151	pre-1919 Flat	3,771	4,829	10,720	16,252	21,137	24,194	25,197	26,356	27,564	28,937	30,527	35,245	36,609	38,123	40,423
	152	1919-1944 Flat	3,333	5,650	19,995	29,755	37,276	41,250	43,043	45,242	47,745	50,409	53,378	60,810	63,230	65,696	69,469
	153	1945-1964 Flat	2,818	3,854	10,110	15,325	20,248	23,181	24,341	25,450	26,647	28,345	30,093	34,941	36,418	37,954	40,080
	154	1965-1974 Flat	1,893	3,937	14,091	21,611	27,890	31,617	33,361	35,415	37,592	40,096	43,037	50,611	53,106	56,083	60,278
	155	1975-1985 Flat	1,766	2,832	10,445	17,309	24,148	28,543	30,883	32,482	33,791	35,894	37,800	44,219	45,479	46,953	48,915
	158	post-1985 Flat	1,687	2,506	10,523	18,226	25,094	31,019	33,479	35,086	36,068	38,273	40,347	46,615	47,477	48,754	50,319

Figure A.1: Example of MCM's Depth Damage Data for Residential Properties

A.2 RECORDING DAMAGE ASSESSMENT DATA

Damage assessments are carried out to quantify the economic risk to the study area. This requires many details to be recorded such as background data, interim calculations, and final damage results. RPS creates geo-referenced shapefiles with relevant data recorded in their attribute tables. Each flood mechanism to be assessed requires a building polygon shapefile and a damage assessment point file.

Building polygon shapefiles are created to contain background data for building polygons including building use and area. These commonly originate from datasets provided by the relevant local authority.

Damage assessment point files are created to contain all information needed to complete the damage assessment. Information such as building area, finished floor level (FFL) thresholds and water elevations extracted from the modelled flood events are combined into this shapefile to give flood depths referenced to finished floor level for each simulated event. These shapefiles are used to display economic risk of properties relating to a range of flood events.

The following sections detail how damage assessments are carried out and the data that is recorded during various processes.

A.3 CATEGORISATION OF PROPERTIES

All properties within the largest modelled floodplain/s are surveyed and classified according to latest MCM guidelines. Based on the level of assessment (full-scale detailed / Flood Relief Scheme), the following attributes may be recorded for residential properties; property type, age and social class. Social class data is provided in the MCM based on social classes AB, C1, C2 and DE based on England and Wales. As social class data is not collated under the same categories and methodology in Ireland as in England and Wales, these cannot be made comparable. As such, social class is not considered in economic damage assessments in Ireland.

The MCM assigns a code to each property type to aid the damage calculations. Table A.1 and Table A.2 detail the various residential and non-residential property types.

Table A.3.1: Residential Properties MCM Codes

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

Table A.3.2: Non-Residential Property MCM Codes

MCM CODE	PROPERTY TYPE
2	Retail
3	Offices
4	Warehouses
5	Leisure and Sport
51	Leisure
52	Sport
521	Playing Field
523	Sports Centre
526	Marina
525	Sports Stadium
6	Public Buildings
8	Industry
9	Miscellaneous
910	Car park
960	Sub-Station

Depth damage data is not provided for garages and sheds in the MCM. Properties classified as garages, sheds, or other buildings which will not incur damage are classified with the MCM code -999, and are screened out prior to the next stage in the assessment.

The following categorisation details are recorded for each building within the largest modelled flood extent:

Table A.3.3: Categorisation of Properties Data

Data Type	Attribute Name	Data Details
Property Use	use	"R" for residential and "C" for commercial
Property Type	prop_type	As per MCM guidelines
MCM Code	Mcm_code	As per MCM guidelines
Business Type	bus_type	“l” for local business “n” for not local business
Floor Area	area	Floor area of the property

A.4 PROPERTY THRESHOLD LEVEL

The damage assigned to a property relates to the depth of water above floor level. As such the threshold level of all properties is required as part of the damage assessment. As a general rule most properties are constructed with the floor level raised 300mm above the adjacent ground level. This would be particularly characteristic of fluvial or coastal floodplains which are generally low lying and flat in nature. Steep topography

also has an influence on finished floor levels whereby some properties have split level front doors and back doors and some properties enter at ground level but have basements below.

Where a finished floor level (FFL) threshold survey has been carried out, FFLs are directly transposed into the damage assessment shapefile(s). These are considered the most accurate method of providing FFLs. RPS ensure that any FFL surveys which are carried out specify the surveyor to use a total station, to avoid errors induced by differential GPS stations being used close to buildings which reduced the accuracy due to disturbing clear lines of sight to GPS satellites. In the occurrence of multiple entrances to a property being surveyed, a conservative threshold is chosen based on the lowest level surveyed for the FFL. For Flood Relief Schemes threshold surveys are commonly undertaken for all properties at risk of flooding within a study area, as defined through the CFRAM Study assessment.

In absence of FFL surveys, RPS calculate the average level from LiDAR across the building footprint to provide a ground level. A survey of steps into the property allows the height the FFL is raised to be estimated. Each step is counted as +150mm above LiDAR defined ground level. For example, if there are two steps the raised height above ground level would be 300mm. Table A.4.1 shows the details recorded in the damage assessment shapefile. QA checks are carried out to ensure damages are not over / underestimated, with any manual updates recorded in the attribute tables of the shapefile.

Table A.4.1: Property Threshold Data

Data type	Attribute name	Data details
Ground Level	gl	LiDAR data extracted at each property (average level across building footprint), measured in mOD Malin. Where a FFL survey is available a null value of '-999' is recorded.
Finished Floor Level	ffl	Where FFL surveys exist these will supersede any assumptions made regarding the ground level and raised height to account for steps. For properties with basements FFL (and not surveyed) is calculated to be ground level minus 2.5m.

A.5 FLOOD DEPTH OF PROPERTIES

To estimate the damage to a property, estimations of predicted flood depths are required for a wide range of flood events. The depths to which properties in the assessment are flooded are calculated for modelled events prescribed in the brief; for Irish assessments the events prescribed are commonly 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100, 1 in 200 and 1 in 1000 year.

The depth of flooding is calculated by finding the difference between the flood water elevation and the estimated threshold level. The flood elevations are extracted from the hydraulic model outputs to find the maximum depth of water touching each building polygon for each event. This process is achieved by carrying out a statistical analysis in ArcGIS. Table A.5.1 below shows details which are recorded within the attribute tables of the damage assessment shapefile:

Table A.5.1: Flood Depth of Properties Data

Data type	Attribute name*	Data details
Flood level for all flood events	wl_50pc, wl_20pc, wl_10pc, wl_5pc, wl_2pc, wl_1pc, wl_05pc, wl_01pc.	The maximum flood level adjacent to the building (mOD) for each flood event.
Flood depth for all flood events	dp_50pc, dp_20pc, dp_10pc, dp_5pc, dp_2pc, dp_1pc, dp_05pc, dp_01pc.	Difference between the flood level and FFL.

* the attribute names correspond to the annual exceedance probability (AEP) of a flood event. A 50pc corresponds to a 50% AEP

A.6 FLOOD DAMAGE TO PROPERTIES

Once the depths of flooding are known the damage can be calculated using the MCM depth damage data. This is known as direct damage in that the flooding directly damages assets; it does not account for indirect damages such as heating costs to dry out the house. For each property type, a typical damage based on historical data has been assigned to a depth of flooding. The latest version of the MCM data is sourced, where the damage per square metre of the floor area of a building is used (for both residential and non-residential properties). This assessment adopted the fluvial depth damage data using the Long Duration Major Flood Storm (2020-2021 Price base) for residential properties and the Long Duration No Warning Without Cellar (2020-2021 Price base).

The direct damage in each flood event for each building in pounds sterling prices per square metre is calculated by interpolating between the depth damage figures provided in the MCM guidance and is converted to euros. This damage figure is then multiplied by the floor area of the property to give the total damage. This information is recorded in the attributes listed in Table A.6.1.

Table A.6.1: Flood Damage to Properties Data

Data type	Attribute name	Data details
Direct damage per meter square	m2dm_50pc, m2dm _20pc, m2dm _10pc, m2dm _5pc, m2dm _2pc, m2dm _1pc, m2dm _05pc, m2dm _01pc.	Damage per meter square (£/m^2) to each property according to the depth of flooding from each flood event as per MCM data.

Data type	Attribute name	Data details
Floor Area Damage	fadm_50pc, fadm _20pc, fadm _10pc, fadm _5pc, fadm _2pc, fadm _1pc, fadm _05pc, fadm _01pc.	Damage per meter square multiplied by floor area of building (£).
Principal Direct Damage (PDD) - Damage to property over full floor area	pdd_50pc, pdd _20pc, pdd _10pc, pdd _5pc, pdd _2pc, pdd _1pc, pdd _05pc, pdd _01pc.	Damage per meter square multiplied by floor area of building (converted to €).

A.7 INTANGIBLE IMPACTS OF FLOODING

Apart from the material damages to the building structure and the goods inside the property, it is recognised that there are monetary damages associated with stress, health effects and loss of memorabilia, which can be as important as direct material damage to householders. OPW guidance states that intangibles be considered as damages which are equal to the direct property damage for residential properties.

Table A.7.1: Flood Damage to Properties Data

Data type	Attribute name	Data details
Intangible Damage	intd_50pc, intd_20pc, intd_10pc, intd_5pc, intd_2pc, intd_1pc, intd_05pc, intd_01pc.	Equal to the Principal Direct Damage (PDD) - Damage to property over full floor area. Applied only to residential properties.

A.8 INDIRECT COSTS

Indirect costs account for tangible costs incurred that are not included in the direct damages. The MCM provides damage data for a range of indirect costs, which are considered at different economic levels of analysis. Damage assessments for flood studies consider the following indirect costs; emergency, utility costs in-line, with OPW guidance.

A cost will be associated with emergency services dealing with the flood events. Following the Environment Agency's Flood or Coastal Erosion Risk Management (FCERM) appraisal guidance, which the MCM guidance

has been adapted to comply with, a value of 8.1% of the principal direct damages is assigned to the emergency services costs. This figure is based on data collected from previous flood events in the UK.

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

The details in Table A.8.1 are recorded within the economic risk shapefile attribute tables:

Table A.8.1: Emergency and Utility Cost Data

Data type	Attribute name	Data details
Utility costs	util_50pc, util_20pc, util_10pc, util_5pc, util_2pc, util_1pc, util_05pc, util_01pc.	Equal to 20% of the PDD.
Emergency costs	emerg_50pc, emerg_20pc, emerg _10pc, emerg _5pc, emerg _2pc, emerg _1pc, emerg _05pc, emerg _01pc.	Equal to 8.1% of the Principal Direct Damages (PDD).

A.9 EVENT DATA

The event damage is defined as the total of the direct damages in any one event, calculated to be the sum of the principal direct damage (PDD) to properties, intangible damage, emergency costs and utility damages. The event damage is required for later steps in the process, specifically in calculating annual average and present value damages. The event damage is recorded in the damage assessment shapefile as shown in Table A.9.1.

Table A.9.1: Event Damage Data

Data type	Attribute name	Data details
Event Damage	evdam_50pc, evdam_20pc, evdam_10pc, evdam_5pc, evdam_2pc,	Summed direct damage of any one event. This is the total of the PDD, intangible damage, emergency costs and utility damage.

evdam_1pc,
evdam_05pc,
evdam_01pc.

A.10 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE

To gain an appreciation of the economic risk the overall damage needs to be calculated. This is represented by assessing the likelihood of each of these flood events occurring in any given year and applying this as a percentage to the damage; this is known as the Annual Average Damage (AAD). The AAD can then be taken over the lifetime of the study that has been set at 50 years and discounted back to present day costs; this is known as the present value damage (PVD).

The AAD can best be described by considering the graph shown in Figure A.2. The points shown represent the various design flood events where the event damage is calculated. Their position on the graph is dictated by the damage caused and the frequency of the flood event occurring in any given year. These points are joined together to create a damage curve. The area under the curve is therefore a function of the damage and the frequency and gives the AAD.

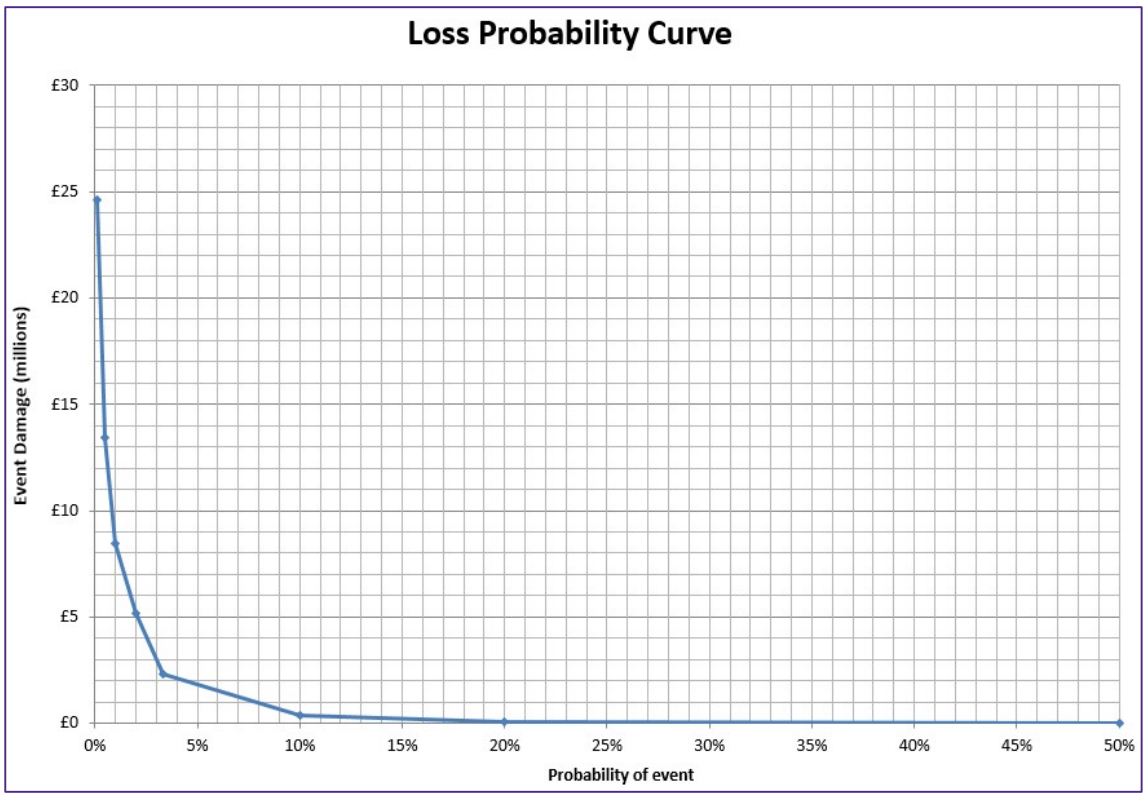


Figure A.2: Example Loss Probability Curve

Once the AAD is calculated the present value damage can be determined. The present value damage calculation sums the AAD that is expected to occur for each of the 50 years considered in Irish studies. In order for the damage value in each year to be comparable with each other they are discounted to represent the equivalent present damage value. Discounting damage values in the future is based on the principle that generally people prefer to receive goods or services now rather than later. This is known as time preference. The cost therefore of providing a flood management option will also be discounted to present day values. A discount rate of 4% is considered, in accordance with OPW CBA methodology.

This results in factoring the AAD by 21.482. The AAD and PVD are calculated for the direct, indirect and intangible damages. Table A.10.1 outlines the details that are recorded within the damage assessment shapefile attribute tables:

Table A.10.1: AAD and PVD Data

Data type	Attribute name	Data details
Annual Average Damage for direct & intangible damages	aad	The equation to calculate the AAD is as follows: (([evdam_50pc]+[evdam_20pc)/2*(0.5-0.2)+ ([evdam_20pc]+[evdam_10pc])/2*(0.2-0.1)+ ([evdam_10pc]+[evdam_5pc])/2*(0.1-0.05)+ ([evdam_5pc]+[evdam_2pc])/2*(0.05-0.02)+ ([evdam_2pc]+[evdam_1pc])/2*(0.02-0.01)+ ([evdam_1pc]+[evdam_05pc])/2*(0.01-0.005)+ ([evdam_02pc]+[evdam_01pc])/2*(0.005-0.001))
Present value damage	pvd	The AAD factored by 21.482, based on a 4% discount rate applied over a 50 year project horizon.

A.11 CAPPING BENEFITS

It is recognised that for certain properties the overall damage can far exceed the market value of the property. This can be due to either the depth to which it floods or the frequency with which it floods or a combination of both factors. To address this issue, any benefit calculated as a result of protecting a property is capped, in accordance with OPW guidance.

When capping benefits for residential properties, the regional average market value is used. Detailed research is carried out in order to establish an accurate and robust representation of property values for the study area. The capping value for residential properties is set at 2 times the market value, in accordance with OPW CBA guidance.

For a non-residential property its capping value is calculated by its rateable value multiplied by a factor of 10, in line with OPW Cost Benefit Analysis (CBA) guidance. Rateable values are not available for the commercial property types set out in the MCM in Ireland as it is for England. Rates for South Western England are used as a surrogate following instruction from OPW.

The details recorded in the attributes are provided in Table A.11.1.

Table A.11.1: Capping Damages Data

Data type	Attribute name	Data details
Present Value Benefit	pvb_def	Present Value Economic Benefit of providing the required Standard of Protection. Calculated by the difference between the PVD of the current and defended scenarios.

Data type	Attribute name	Data details
Annual Average Benefit	aab_def	Calculated as the Annual Average Damage (AAD) factored by the appropriate discount rate.
Capping code	cap_code	Property type as per Multi Coloured Manual (MCM) categorisation capped at an agreed mar&et value for the property in question.
Capping value for property benefit	cap_val	Residential property damages capping value is set at market value x 2 Commercial property damages capping value = rateable value x 10.
Present value benefit capped at market value	pvd_def_c	Where pvb_def is greater than cap_val, the benefit is set equal to the cap_val. If the benefit is less than the capping value this value calculated will be the same as pvb_def.

A.12 DAMAGE ASSESSMENT REVIEW

A review of damage assessments are carried out to quality check the data being used. Some basic checks carried out by the damage assessors include reviewing the properties that contribute over 1% of the capped PVD, checking the area and thresholds of large commercial buildings and spot-checking depth damage data is correctly applied. Checks are also carried out by the modeller, to ensure the model is calibrated to historic events and to inform the optioneering process.

A quality assurance spreadsheet has been developed by RPS to ensure a number of checks are carried out throughout the process, which is included as part of the appendices of any flood risk study which includes a damage assessment.

A.13 SUMMARY OF DAMAGES

Table A.13.1 below summarises the damage assessment showing the annual average damages in Castlefinn and present value damages over a 50-year time period. Damage avoided or benefit values are provided in the summary using capped values and assuming a 1% Annual Exceedance Probability (AEP) flood event Standard of Protection.

Table A.13.1: Damage assessment for Castlefinn

Damage type	Damage Value
Annual average damage	€498,835
Present value damage (undefended)	€10,715,972
Present value damage (defended to 1%AEP SoP)	€1,727,496

Damage type	Damage Value
Present value benefit (defended to 1%AEP SoP)	€8,988,475
Present value benefit CAPPED (defended to 1%AEP SoP)	€6,108,654

A.14 SENSITIVITY ANALYSIS

A sensitivity analysis was carried out whereby lower and upper Discount Rates were used to calculate the present value benefit of the scheme, which then informed the sensitivity analysis for the BCR. Table A.14.1 and Table A.14.2 summarises the damage assessment showing the annual average damages in Castlefinn and present value damages over a 50-year time period assuming 5% and 3% discount rates, respectively. Damage avoided or benefit values are provided in the summary using capped values and assuming a 1%AEP flood event Standard of Protection.

Table A.14.1: Damage assessment for Castlefinn – 5% Discount Rate

Damage type	Damage Value
Annual average damage (Baseline)	€498,835
Present value damage (undefended)	€9,106,730
Present value damage (defended to 1%AEP SoP)	€1,445,861
Present value benefit (defended to 1%AEP SoP)	€7,660,869
Present value benefit CAPPED (defended to 1%AEP SoP)	€5,545,746

Table A.14.2: Damage assessment for Castlefinn – 3% Discount Rate

Damage type	Damage Value
Annual average damage (Baseline)	€498,835
Present value damage (undefended)	€12,835,022
Present value damage (defended to 1%AEP SoP)	€2,037,796
Present value benefit (defended to 1%AEP SoP)	€10,797,226
Present value benefit CAPPED (defended to 1%AEP SoP)	€6,690,829

Appendix B

Scheme analysis and development modelling methodology

B1. SCHEME ANALYSIS AND DEVELOPMENT MODELLING METHODOLOGY

The modelling undertaken to support the Scheme Analysis and Development is Phase 2 of the hydraulic modelling needed to support the FRS (see 1.1 of the Hydraulics Report[1]).

Phase 2 modelling builds on the baseline model to test and analyse the effectiveness of individual measures and in combination as options. The baseline modelling was updated from that reported in the Hydraulics Report before the commencement of the Optioneering tasks. This is discussed in further detail in Section 1.4.

The baseline model is adapted to represent each of the different measures as described below.

B1.1 Hard Defences

Hard defences are represented within either the 1D model or the 2D model depending on where they are located. Where defences are located on river banks, at the interface of the 1D and 2D models, the defence is represented as a raised bank line by adjusting the elevation within the bank line editor in ICM. The elevation is set above the desired height of the hard defence such that the modeller can efficiently determine the maximum height of the water with the defence in place for the required SoP.

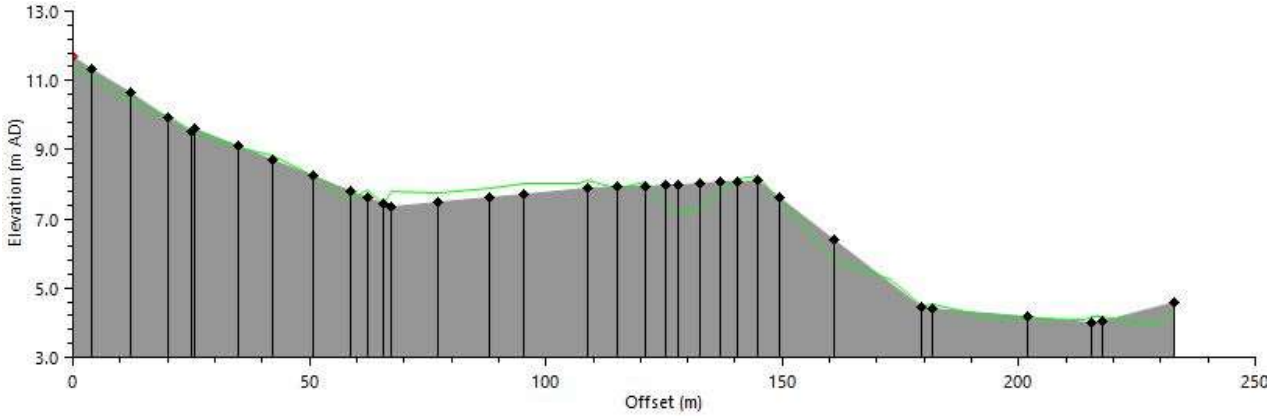


Figure B1.1 – Bank Line representation before hard defences put in place

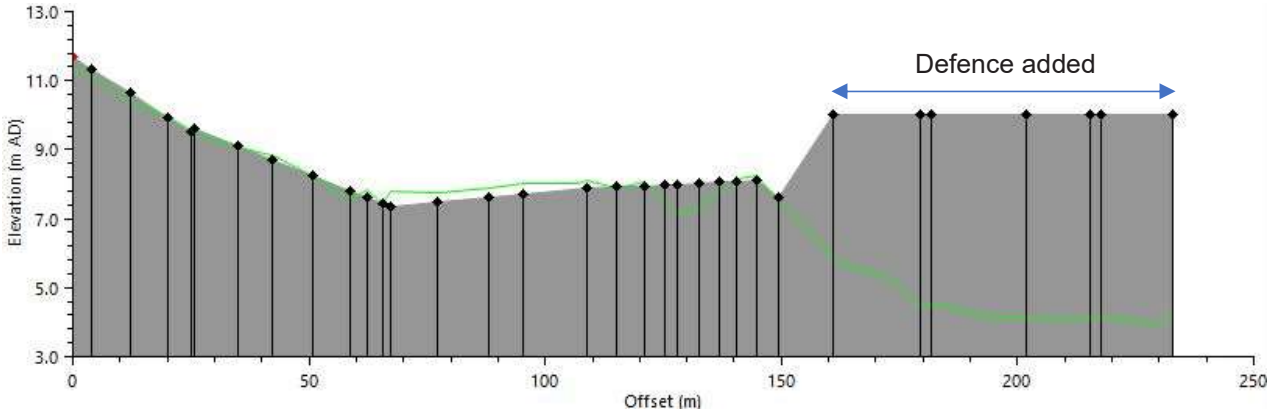


Figure B1.2 – Bank Line representation after hard defences put in place

[1] Castlefinn Flood relief Scheme Hydraulics Report, document no. IBE1760_Rp015, RPS, 2022) available at: https://countydonegalfrs.ie/burnfootfrs/index.php/documents/

Where defences are located within the existing floodplain they are represented as 'porous wall' elements within the ICM model. Again, the crest height / elevation is set above the desired height and then the design elevation of the hard defence is extracted from the model based on the maximum height of the water for the required SoP.

B1.2 Storage

An initial screening of the topography was undertaken to determine potential storage areas. One storage area was identified on the Castlefinn Watercourse within the model extent.

The main storage area identified within the model extent was outside the 2D zone of the model. It was therefore represented as a 1D storage area defined by a storage curve (volume available across the range of potential water elevations). The storage area was first defined on plan based on mapping and the available 5m IfSAR digital terrain data. Using GIS raster processes the DTM area within the defined polygon for various elevations was calculated.

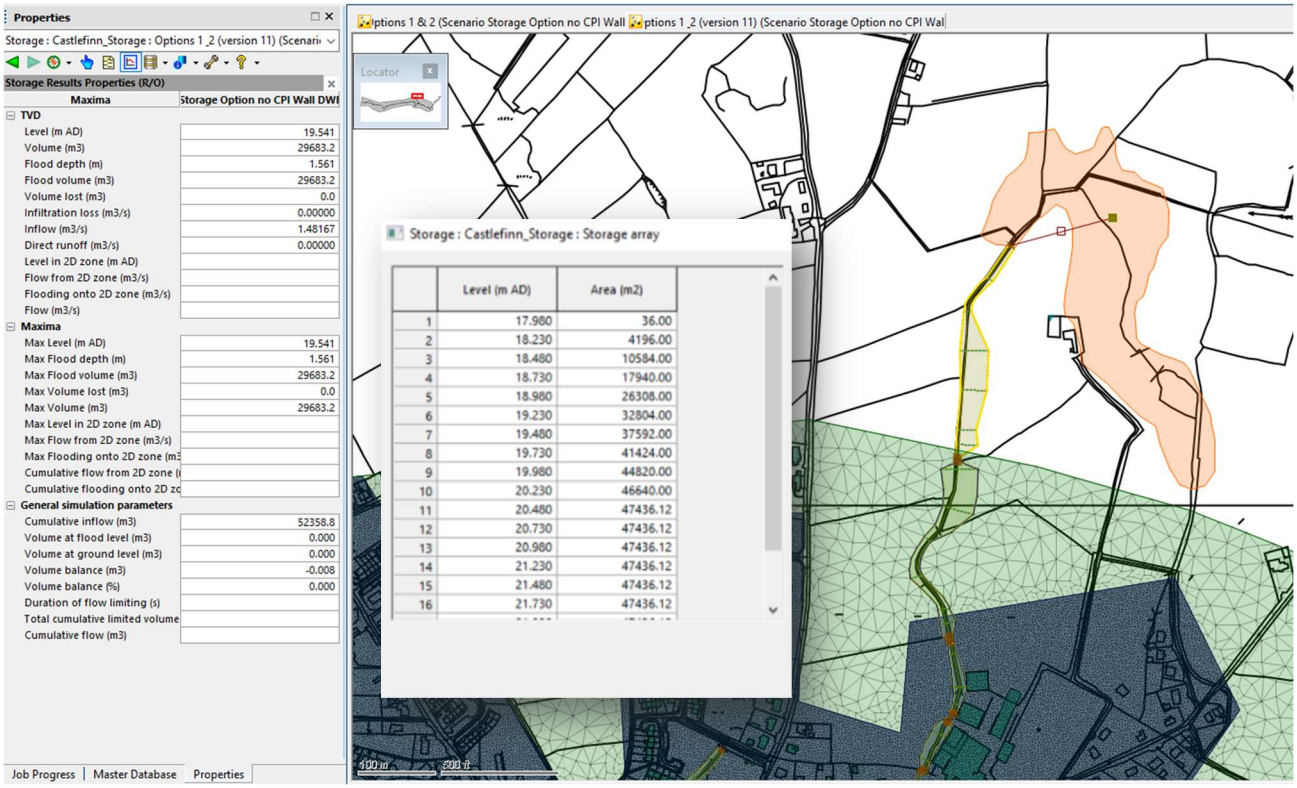


Figure B1.3 – Definition of storage area within the Castlefinn FRS model

The flow control structure is defined by inserting a culvert and headwall structure within the 1D model at the location of the proposed storage dam. A weir within the 1D model defines the spilling point from the storage area.

The culvert in the 1D model is then sized to restrict the flow in the river channel to the desired flow. This allows water to back up within the 1D model upstream of the culvert and fill the storage area. If the storage volume

available is exceeded, the weir is overtopped and excess flows are released down the 1D model of the watercourse.

A second storage area, directly east of the CPI site was also modelled. Unlike the main storage area this did not require any flow control structure but is simply additional floodplain storage created by excavation. This was achieved within the model by setting a mesh level zone across the area identified and setting the levels in this area to 4m OD to create approximately 4,140m^3 of additional floodplain storage volume.

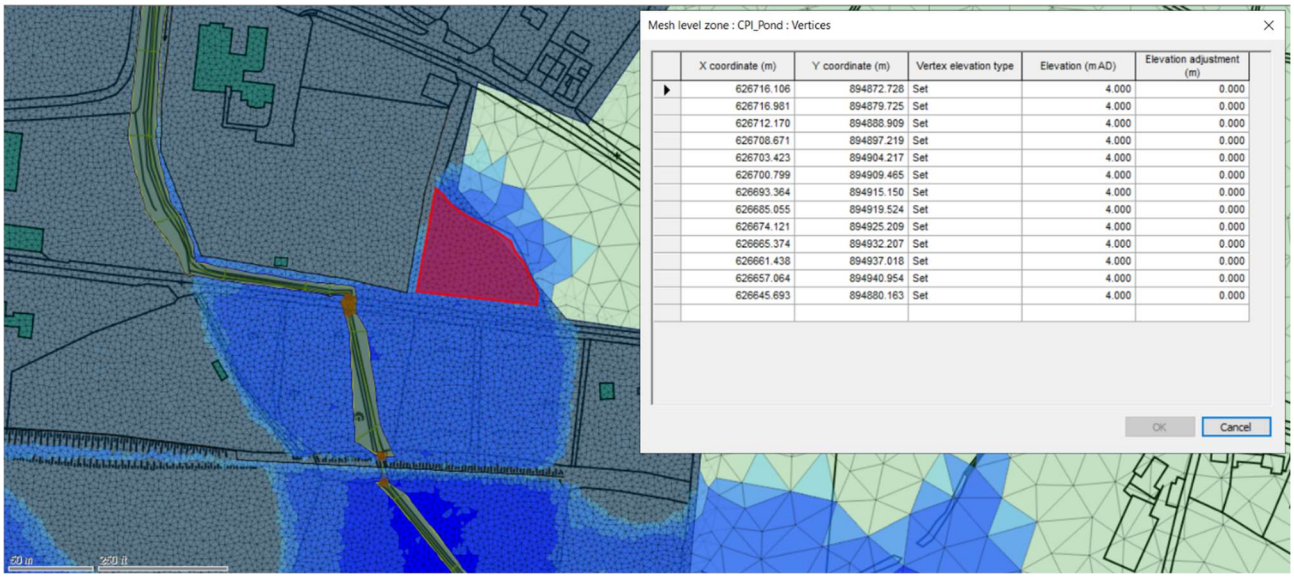


Figure B1.4 – Definition of storage area adjacent to CPI Centre

B1.3 Increased Conveyance

Increasing the conveyance of the channel is achieved by editing the river reach cross sections to represent the widened / deepened channel. Once edited these are then built into the river reach element of the model in the usual way in ICM. Alternatively, the river reach cross sections themselves can be directly edited without altering the cross-section and background data (typically imported from the survey).

Increasing the conveyance of structures such as culverts is done by editing the structure parameters. In the case of culverts, it may simply be the case that the conduit element dimensions are increased / decreased within the structure definition table. In the case of the Bridge Burn culvert, a new culvert route with manholes, new inlet and outlet structures was tested.

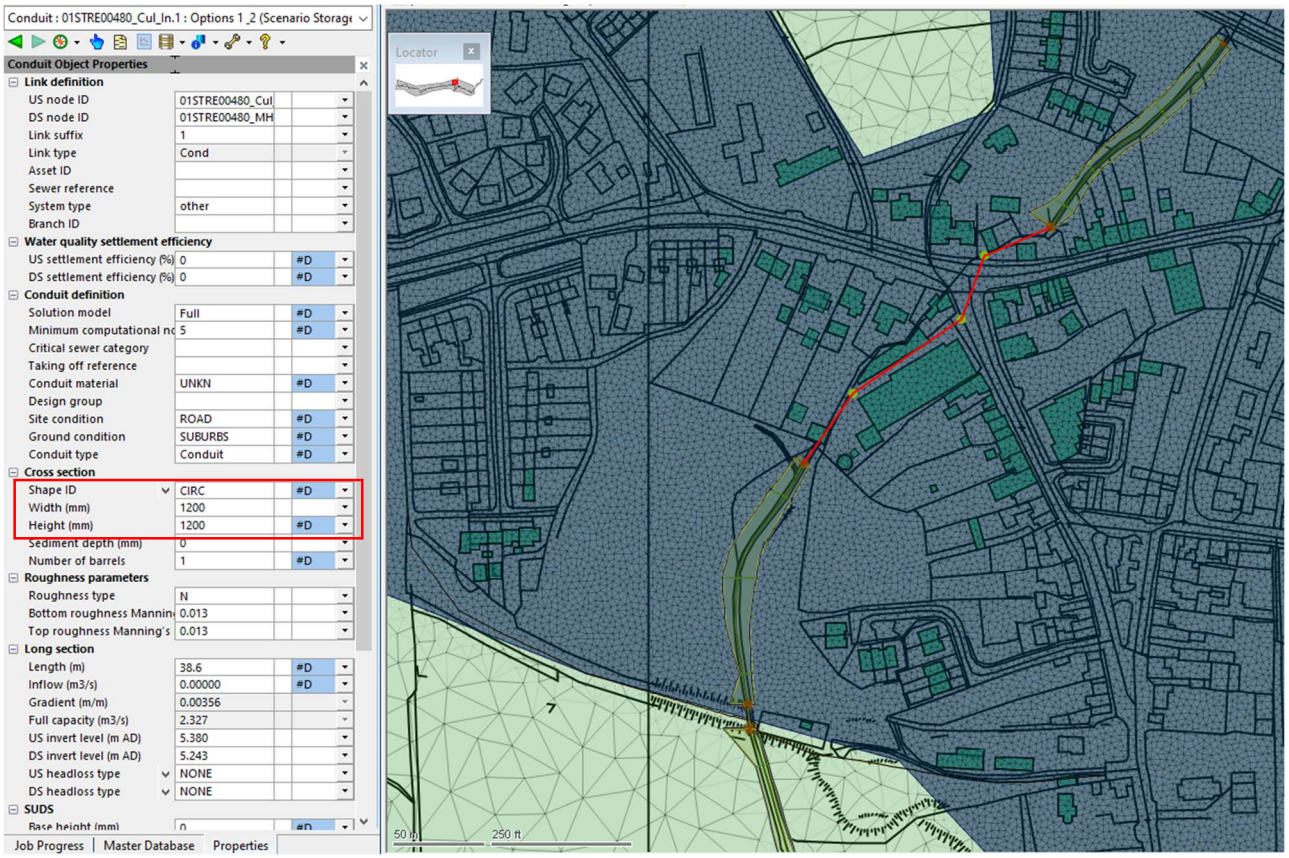


Figure B1.5 – Definition of new Bridge Burn culvert within the Castlefinn FRS model

B1.4 Upstream and Downstream impacts

The impact of the preferred option was assessed both upstream and downstream of the proposed scheme. Table B1 show the impact to flood levels and flows immediately upstream and downstream of the scheme area on the River Finn. It can be seen that while there is a difference to flows resulting from the proposed scheme there is minimal variation to flood levels.

Table B.1: Flood Flows and Levels Upstream and Downstream of Castlefinn for Pre-Scheme and Post-Scheme 1% AEP Scenario

Location	Pre-Scheme Flow (m^3/s)	Pre-Scheme Level (mOD)	Post-Scheme Flow (m^3/s)	Post-Scheme Level (mOD)
US Castlefinn (CAST_03)	633	7.694	650	7.701
DS Castlefinn (CAST_15)	541	7.458	518	7.462

Appendix C

Seepage Analysis

C1. CASTLEFINN FLOOD PROTECTION SCHEME – OPTIONS APPRAISAL (GEOTECHNICAL REVIEW)

The proposed Scheme will be formed within and on the outskirts of Castlefinn which sits to the north of the River Finn. The river meanders in an approximate west-east direction passing below the existing masonry double arch bridge, which conveys the R235 over the river and provides access to the town. The proposed scheme is at the early stages and as such three options are currently being considered.

One of the options considers the construction of an embankment/dam approximately 1km north-east of Castlefinn to provide storage.

As part of the assessment process for the Castlefinn Flood Relief Scheme a geotechnical assessment of the options proposed has been undertaken to identify potential geotechnical issues predominately in relation to seepage and founding strata of structures.

The purpose of this appendix is to summarise geotechnical information from desk-based sources, highlight risks and constraints associated with construction of the scheme and identified associated geotechnical risks. Ground investigation will be undertaken to inform the development of the scheme design.

C1.1 Anticipated Geology

A review of the publicly available information relating to geology has been undertaken to inform the likely conditions in the absence of site specific exploratory holes for the scheme.

Artificial Ground / Made Ground

Artificial deposits and made ground are present at Castlefinn in a number of locations, most notably at the CPI Centre which appears to be developed on an area elevated through made ground. The existing railway embankments and the recently constructed defence built along part of the railway embankments south of the CPI are also likely to contain made ground deposits. It is expected that artificial ground or made ground deposits are likely to be present associated with other developments in Castlefinn i.e. road construction, housing development works etc.

Drift Geology

The site is generally underlain by Till deposits likely to comprise clays, silts, sand and gravel with a number of bedrock outcrops/sub crops present around Castlefinn. Where the scheme is in close proximity to the River Finn alluvium comprising of unconsolidated layers of clay, silt, sand and gravel is present.

Bedrock

The site is underlain by bedrock of the Mullyfa and Deele Formations in the western portion of the site, comprising psammite, pebble beds, marble, schist. The eastern portion of the site is underlain by bedrock of the Aghyaran & Killygordon Limestone Formation, consisting of marble, quartzite, psammite; graphitic.

No historical exploratory records were available at the time of this review.

C1.2 Proposed Scheme

As part of the proposed scheme the following options for flood protection are being considered:

- Flood Embankments
- Flood Wall (reinforced concrete or similar)
- Flood wall to riverbed level (Sheet piles or similar)
- Storage areas
- Culvert upgrades

All three options require four culverts to be upgraded within Castlefinn, two within the town and two to the south of the town. These haven't been assessed as part of this assessment.

C1.3 Geotechnical Assessment

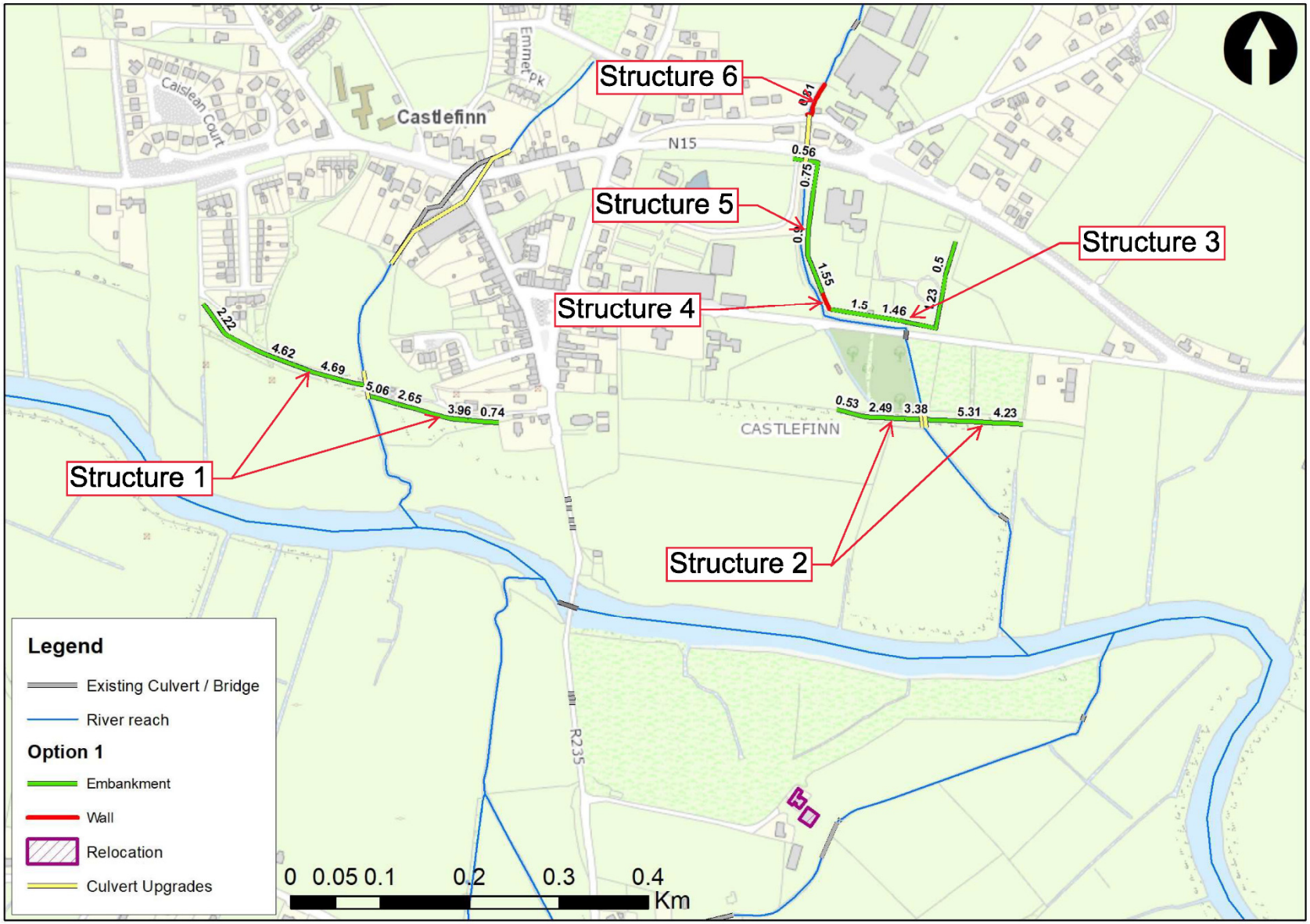
As part of the geotechnical assessment an estimate of the likely seepage at each location has been made based on the publicly available geological information and potential constituents making up the various geological strata.

Where the proposed structure is indicated to be underlain by alluvium this has been deemed to have a medium seepage potential based on the unconsolidated deposits of clay, silt, sand and gravel providing a pathway for groundwater through the more granular lenses.

Where the proposed structure is indicated to be underlain by till this has been deemed to have a low seepage potential based on the main constituents being clay or silt with secondary constituents of both sand and gravel. Where the main constituents are sand and gravel the seepage potential would increase.

The above assumptions will require to be confirmed through ground investigation works to inform detailed design and identify any risks associated with design and construction.

Option 1


Structure 6
Structure 5
Structure 4
Structure 3
Structure 1
Structure 2
Castlefinn
Caislean Court
Emmet Pk
N15
CASTLEFINN
R235
0.91
0.56
0.75
0.9
1.55
0.5
1.23
1.5
1.46
2.22
4.62
4.69
5.06
2.65
3.96
0.74
0.53
2.49
3.38
5.31
4.23
Legend
Existing Culvert / Bridge
River reach
Option 1
Embankment
Wall
Relocation
Culvert Upgrades
0 0.05 0.1 0.2 0.3 0.4
Km

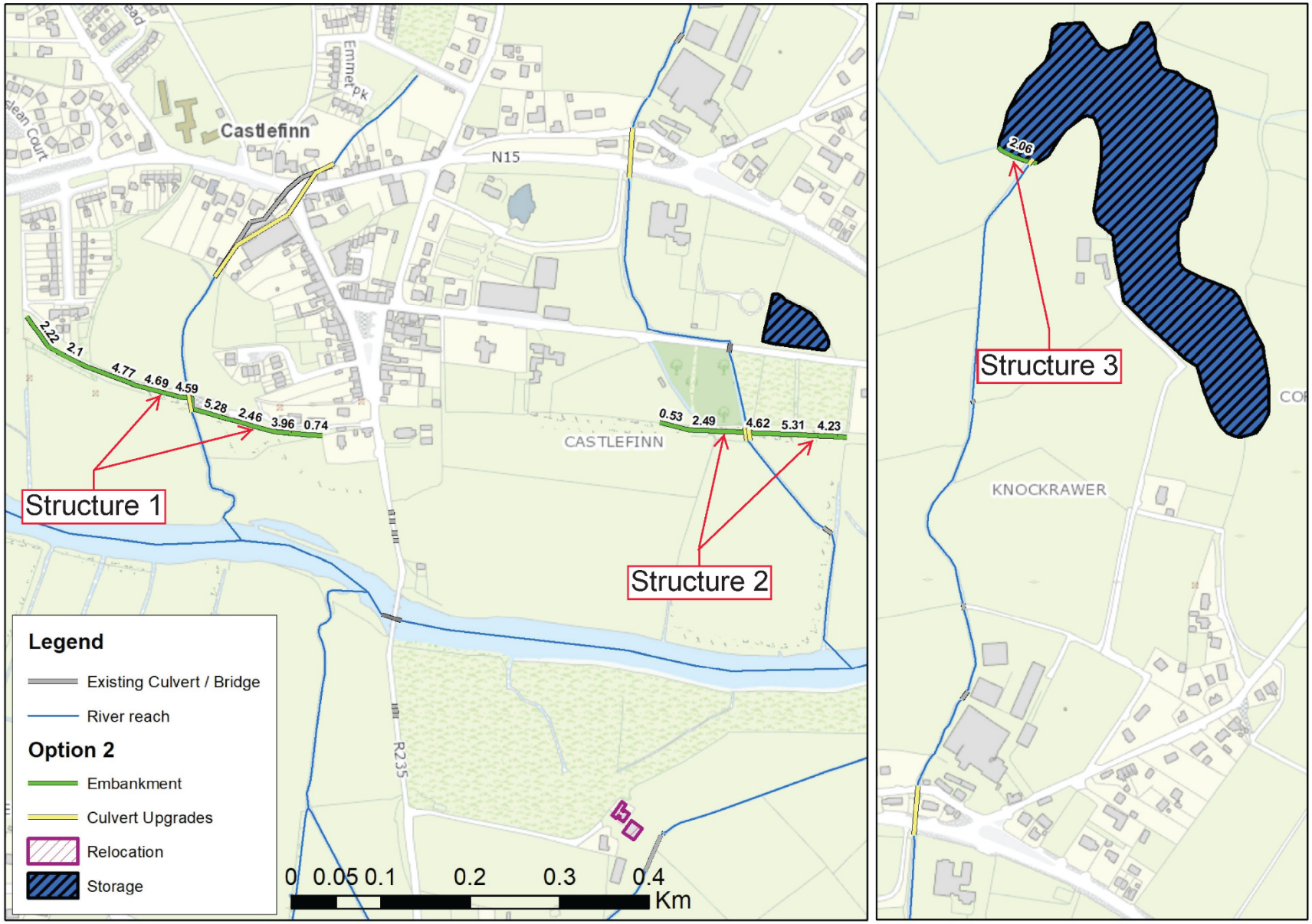
Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
1	Alluvium / Till	0.74 – 5.06	Low to medium	Embankment	Wall	• It is deemed that an embankment is the most suitable solution at Structures 1 & 2 due to the following: o Low to high height of protection required o No space constraints which may impact embankment construction o Generally open land behind defences which could accomodate an element of seepage. Some areas (east and western ends of structure 1) with properties close to rear of defence. These properties are partially elevated and unlikely to be affected by seepage. • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.
2	Till / rock	0.53 – 5.31	Low	Embankment	None	
3	Made Ground	0.5 – 1.5	Medium to High	Embankment	Flood Wall	• It is deemed that an embankment is the most suitable solution for this location due to the following: o Low height of protection required o No space constraints which may impact embankment construction o Limited properties and open land which could accommodate an element of seepage • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.

Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
4	Made Ground	1.5 – 1.55	Medium to High	Flood Wall	Sheet piled wall with coping	• It is deemed that a flood wall is the most suitable solution for this location due to the following: o Low height of protection required o Space constraints limiting what can be constructed • An element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall. • Where a flood wall to the riverbed is considered as an alternative, minimum works would be required to construct the proposed wall with the exception of any working platform requirements where a piling rig as opposed to a machine mounted pile driver was utilised.
5	Made Ground	0.56 – 1.55	Medium to High	Embankment	Flood Wall	• It is deemed that an embankment is a suitable solution for this location due to the following: o Low height of protection required An embankment may not be suitable if it is deemed through detailed GI and design that the seepage rates are likely to be high. • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where the level of seepage is deemed unacceptable due to close proximity of the properties and roads then an alternative of a wall would be required to provide the required cut-off. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.

Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
6	Made Ground	0.81	Medium to High	Flood Wall	Sheet piled wall with coping	• It is deemed that a flood wall is the most suitable solution for this location due to the following: o Low height of protection required o Space constraints limiting what can be constructed o Close proximity to properties resulting in low seepage requirements • An element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall. • Where a flood wall to the riverbed is considered as an alternative, minimum works would be required to construct the proposed wall with the exception of any working platform requirements where a piling rig as opposed to a machine mounted pile driver was utilised.

Note: m AEGL = height above existing ground level

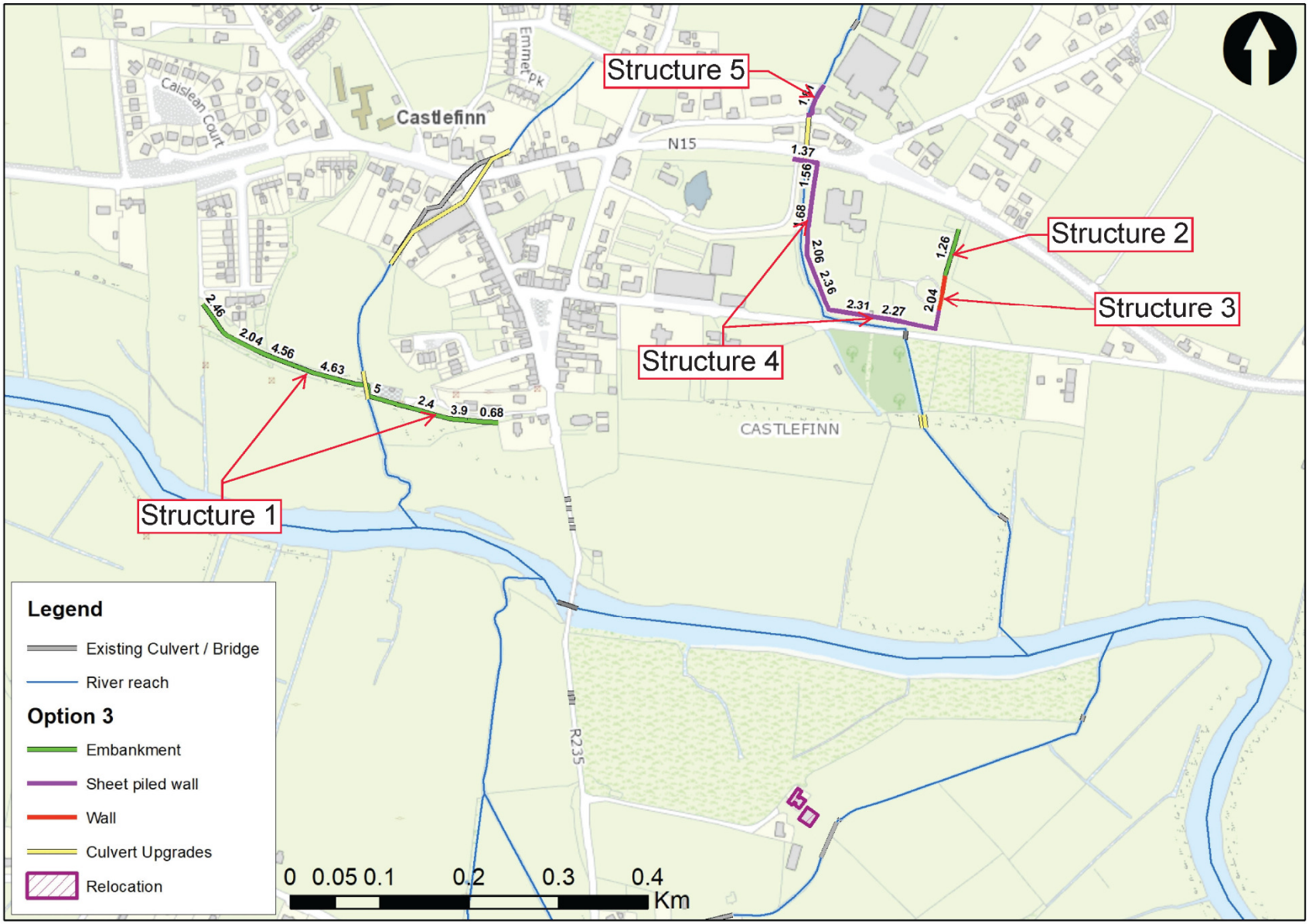
Option 2


Castlefinn
N15
Emmet pk
CASTLEFINN
KNOCKRAWER
R235
2.22
2.1
4.77
4.69
4.59
5.28
2.46
3.96
0.74
0.53
2.49
4.62
5.31
4.23
2.06
Structure 1
Structure 2
Structure 3
Legend
Existing Culvert / Bridge
River reach
Option 2
Embankment
Culvert Upgrades
Relocation
Storage
0 0.05 0.1 0.2 0.3 0.4
Km

Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
1	Alluvium / Till	0.74 – 5.28	Low to medium	Embankment	None	• It is deemed that an embankment is the most suitable solution at Structures 1 & 2 due to the following: ○ Low to high height of protection required ○ No space constraints which may impact embankment construction ○ Generally open land behind defences which could accomodate an element of seepage. Some areas (east and western ends of structure 1) with properties close to rear of defence. These properties are partially elevated and unlikely to be affected by seepage. • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.
2	Till / rock	0.53 – 5.31	Low	Embankment	None	
3	Till	2.06	Low	Embankment	None	• It is deemed that an embankment is the most suitable solution for this location due to the following: ○ Medium height of retention structure required ○ No space constraints which may impact embankment construction ○ Predominately open area of land behind the proposed embankment which could accommodate an element of seepage. • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level.

Note: m AEGL = height above existing ground level

Option 3


Structure 5
Structure 2
Structure 3
Structure 4
Structure 1
Castlefinn
Caislean Court
Emmet pk
N15
CASTLEFINN
R235
1.41
1.37
1.56
1.68
2.06
2.36
2.31
2.27
2.04
1.26
2.46
2.04
4.56
4.63
5
2.4
3.9
0.68
Legend
Existing Culvert / Bridge
River reach
Option 3
Embankment
Sheet piled wall
Wall
Culvert Upgrades
Relocation
0 0.05 0.1 0.2 0.3 0.4
Km

Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
1	Alluvium / Till	0.68 – 5.0	Low to medium	Embankment	Flood Wall	• It is deemed that an embankment is the most suitable solution due to the following: o Low to high height of protection required o No space constraints which may impact embankment construction o Generally open land behind defences which could accomodate an element of seepage. Some areas (east and western ends of structure 1) with properties close to rear of defence. These properties are partially elevated and unlikely to be affected by seepage. • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.
2	Till	1.26	Low	Embankment	Flood Wall	• It is deemed that an embankment is the most suitable solution for this location due to the following: o Low to high height of protection required o No space constraints which may impact embankment construction o Limited properties and open land which could accommodate an element of seepage • A starter layer or basal geotextile may be required to allow the embankment to be constructed, especially where soft/loose materials are present at sub-formation level. • Where a flood wall is considered as an alternative an element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall.

Structure Reference	Likely Ground Conditions	Minimum Height of protection (m AEGL)	Seepage Potential	Proposed Structures	Alternative Structures	Comments/Risk
3	Made Ground	2.04	Medium to High	Flood Wall	Sheet piled wall with coping	• It is deemed that a flood wall is the most suitable solution for this location due to the following: o Low height of protection required o Limited space for construction • An element of excavation and replacement may be required where the materials at sub-formation level are not suitable to support the proposed bearing pressures from the wall. • Where a flood wall to the riverbed is considered as an alternative, minimum works would be required to construct the proposed wall with the exception of any working platform requirements where a piling rig as opposed to a machine mounted pile driver was utilised.
4	Made Ground	1.37 – 2.36	Medium to High	Flood Wall (Riverbed) Sheet piled wall with coping	None	• It is deemed that a flood wall to riverbed level is the most suitable solution for Strcutures 4 and 5 due to the following: o Low to medium height of protection required o Limited space to construct a protection structure. • Minimum works would be required to construct the proposed wall with the exception of any working platform requirements where a piling rig as opposed to a machine mounted pile driver was utilised.
5	Made Ground	1.81	Medium to High	Flood Wall (Riverbed) Sheet piled wall with coping	None	

Note: m AEGL = height above existing ground level

Appendix D

MCA appraisal sheets

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Ryan Dodson**
Name of assessor	**Mark Wilson, Mark Magee, Niall Matthews**
Date of Assessment	**28/04/2022**
Option ID	**Option 1**
Option Type	Structural Option
Option Spatial Scale of Assessment (SSA)	Castlefinn
Option Details	Hard Defences (in.CPI Bund) & Culvert Upgrades
AEP	1.0%
Option Cost	€6,678,400.00
Economic Benefit	€6,108,654.00

This MCA report should be read in conjunction with the OPW Technical Guidance Note - Option Appraisal and the Multi-Criteria Analysis Framework.

Multi-Criteria Analysis Summary

Castlefinn Option 1

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention but some maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working near water, Work which puts persons at risk of burial under earthfall., Heavy plant and machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Technical Score	900

Multi-Criteria Analysis Summary

Castlefinn Option 1

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	3.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 223,236.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 41,527.00	*Defended Scenario*
Total Option Score	4.1	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**291**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	114.3	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.8	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**244**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	163.5	*Sum of factored scores for each utility infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	4.3	*Sum of factored scores for each transport utility receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**341**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	4.0	*Agricultural land downstream of Castlefinn is highly productive. Overall the agricultiral land around Castlefinn is considered good quality*
Option Scoring		
Total Option Score	0	*The River Finn flood defences will result in negligible changes to flood extent and depth upstream and downstream of Castlefinn.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	875

Multi-Criteria Analysis Summary

Castlefinn Option 1

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	4.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	4.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**612**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.5	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**203**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the non-residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.4	*Sum of the factored scores for all of the non-residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.6	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**160**	*Global weighting x Local weighting x Total option score*

Social Score	974

Multi-Criteria Analysis Summary

Castlefinn Option 1

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	3	*Hydromorphology - The water courses that will be affected by the scheme are very low grade and surveys have established that they are unclassified in terms of fisheries habitat and heavily polluted, including organic pollution from sewage and nutrients. The water courses are significantly altered and the culverts are sub standard. The scheme will not significantly impact on the hydromorphology of these watercourses and will result in an improvement in the existing culverts, however the absence of suitable fish habitat, the heavily polluted nature of the water courses mean that salmonids fish are not likely to use these water courses* *Biota - Short term impacts from construction could result in negative impacts from a physico- chemical perspective through the hydraulic pathways to the River Finn but this will be short term and can be mitigated (Score = -1)* *Physico- chemical - WWTP is at risk of flooding and surveys have identified sewage as a particularly pressure on the Bridge Burn Water Course as well as septic tanks. The protection of the WWTP will reduce the pollution during flood events and therefore is a positive (Score = 4).*
Weighted Option Score	**240**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	4.0	*River Finn SAC immediately downstream and is hydrologically connected.*
Option Scoring		
Total Option Score	0	*Evidence of otter activity was noted during field surveys along the banks of the River Finn but remote from this option. The other Qualifying Feature that could potentially be impacted is Atlantic Salmon and indirect effects as a result of the construction particularly sediment run-off and oils and chemicals could impact on the water quality in the downstream SAC (Score -5). Water quality is currently not adequate to support good ecological status which is required for Atlantic Salmon. Whilst the temporary construction impacts could have an impact on water quality there there will be a significant benefit in terms of eliminating sources of flood event pollution runoff incidents by protection the WWTP and properties which is a positive outcome of this option (Score = 4).* *Protected Species Surveys noted that there was some potential for bat (Annex I roosts in a number of trees within the study area, however all options will result in a similar impact in terms of Bats and suitable mitigation will be possible. No otter activity was noted in the works area.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The riparian zone of the Castlefinn River is not particularly sensitive and with improved grassland being dominant habitat there is some wet grassland, freshwater swamp and woodlands near the location of the proposed embankments but these are unlikely to be impacted directly, although some tree felling may be required for access. There are no areas of national regional or local conservation designations directly affected by the scheme. Downstream designations include Finn River SAC. The Protected species survey did note bat potential in some of the trees in close proximity to the embankments but mitigation should be possible. Score = -3* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Option Scoring		
Total Option Score	-2.0	*Potential localised loss or disturbance to the flora/fauna from embankments and floodwalls adjacent to the alignment of the old railway embankment.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*Whilst the water courses that could be directly impacted by the schemes are unclassified for fish habitat and are heavily polluted the River Finn SAC is directly downstream and Atlantic Salmon is a qualifying feature.*
Option Scoring		
Total Option Score	-4.0	*Atlantic Salmon as a qualifying feature of the Finn SAC could potentially be impacted through indirect effects as a result of the construction particularly sediment run-off and oils and chemicals impacting on the water quality in the downstream SAC (Score -5). Water quality is currently not adequate to support good ecological status which is required for Atlantic Salmon. Whilst the temporary construction impacts could have an impact on water quality there is an opportunity to reduce impacts from the WWTP during flood events which is a positive outcome of this option (Score = 1). Vibrational effects from the piling will also be considered as a potential impact and this can be mitigated through appropriate timing of the works.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the habitat in the area of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**-260**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The nature of the Finn Valley LCA, namely good quality agricultural riverine lands of semi-improved geometric fields, with scattered farms, farmsteads and one-off rural dwellings served by a number of rural villages and towns, means that there is greater capacity to assimilate additional development.*
Option Scoring		
Total Option Score	-1.0	*Earthen embankments constructed within the Finn Valley LCA will not have a significant permanent impact due to their location along existing railway embankments. They will not obstruct views from the town across the Finn Valley due to their location within low points in the topography. However there will be short term local impacts due to the visibility of construction sites within the LCA.*
Weighted Option Score	**-24**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*A number of sites/features Recorded by NIAH are present and potentially affected with a moderate to low vulnerability*
Option Scoring		
Total Option Score	-1.0	*Changes to the setting of architectural features (NIAH) such that it is slightly changed.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*A number of sites listed on the RMP/RPS present and potentially affected. (high t0 moderate vulnerability)*
Option Scoring		
Total Option Score	-1.0	*The construction of a new flood embankment although outside of the zone of influence of Castle could change the character and setting slightly. All monuments are outside of flood extents so no additional protection is provided under this option.*
Weighted Option Score	**-12**	*Global weighting x Local weighting x Total option score*

Environmental Score	-94

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Ryan Dodson**
Name of assessor	**Mark Wilson, Mark Magee, Niall Matthews**
Date of Assessment	**28/04/2022**
Option ID	**Option 2**
Option Type	Structural Option
Option Spatial Scale of Assessment (SSA)	Castlefinn
Option Details	Option 2 Hard Defence, Culvert Upgrades and Storage
AEP	1.0%
Option Cost	€7,139,274.00
Economic Benefit	€6,108,654.00

This MCA report should be read in conjunction with the OPW Technical Guidance Note - Option Appraisal and the Multi-Criteria Analysis Framework.

Multi-Criteria Analysis Summary

Castlefinn Option 2

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention but some maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working near water, Work which puts persons at risk of burial under earthfall., Heavey plant and machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	-1	*The adaptability of the storage measure is uncertain given the proximity to the neighbouring farm. May require significant additional measures for adaptation.*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Technical Score	800

Multi-Criteria Analysis Summary

Castlefinn Option 2

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	3.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 223,236.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 41,527.00	*Defended Scenario*
Total Option Score	4.1	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**291**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	114.3	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	2.1	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**245**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	163.5	*Sum of factored scores for each utility infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	4.3	*Sum of factored scores for each utility infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**341**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	4.0	*Agricultural land downstream of Castlefinn is highly productive. Overall the agricultiral land around Castlefinn is considered good quality*
Option Scoring		
Total Option Score	-2	*The River Finn flood defences will result in negligible changes to flood extent and depth upstream and downstream of Castlefinn. The storage area upstream of Castlefinn on the Castlefinn watercourse will impact lands upstream negatively.*
Weighted Option Score	**-96**	*Global weighting x Local weighting x Total option score*

Economic Score	781

Multi-Criteria Analysis Summary

Castlefinn Option 2

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	4.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	4.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**612**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.5	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**203**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the non-residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.4	*Sum of the factored scores for all of the non-residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.6	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**160**	*Global weighting x Local weighting x Total option score*

Social Score	974

Multi-Criteria Analysis Summary

Castlefinn Option 2

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	3	*Hydromorphology - The watercourses that will be affected by the scheme are very low grade and surveys have established that they are unclassified in terms of fisheries habitat and heavily polluted, including organic pollution from sewage and nutrients. The water courses are significantly altered and the culverts are sub standard. The scheme at the lower end of the catchment will not significantly impact on the hydromorphology of these watercourses and will result in an improvement in the existing culverts, however the absence of suitable fish habitat, the heavily polluted nature of the water courses mean that salmonids fish are not likely to use these water courses. In the upper catchment the inclusion of online storage on the Castlefinn Water course will not have a significant negative effect on he hydromorphology given he nature of the water course and will not impact on the supporting hydromorphological supporting conditions of the Finn River water body* *Biota - Short term impacts from construction could result in negative impacts from a physico- chemical perspective through the hydraulic pathways to the River Finn but this will be short term and can be mitigated (Score = -1).* *Physico- chemical - WWTP is at risk of flooding and surveys have identified sewage as a particularly pressure on the Bridge Burn Water Course as well as septic tanks. The protection of the WWTP will reduce the pollution during flood events and therefore is a positive (Score = 4).*
Weighted Option Score	**240**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	4.0	*River Finn SAC immediately downstream and is hydrologically connected.*
Option Scoring		
Total Option Score	1	*Evidence of otter activity was noted during field surveys along the banks of the River Finn but remote from this option. The other Qualifying Feature that could potentially be impacted is Atlantic Salmon and indirect effects as a result of the construction particularly sediment run-off and oils and chemicals could impact on the water quality in the downstream SAC. The extent of the embankment works is less given that the upstream storage will remove the need for secondary defences at the CPI centre, therefore this scores marginally better that option 1 (-4). Water quality is currently not adequate to support good ecological status which is required for Atlantic Salmon. Whilst the temporary construction impacts could have an impact on water quality there there will be a significant benefit in terms of eliminating sources of flood event pollution runoff incidents by protection the WWTP and properties which is a positive outcome of this option (Score = 4).* *Protected Species Surveys noted that there was some potential for bat (Annex I roosts in a number of trees within the study area, however all options will result in a similar impact in terms of Bats and suitable mitigation will be possible. No otter activity was noted in the works area.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**40**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The riparian zone of the Castlefinn River is not particularly sensitive and with improved grassland being dominant habitat there is some wet grassland, freshwater swamp and woodlands near the location of the proposed embankments but these are unlikely to be impacted directly, although some tree felling may be required for access. There are no areas of national regional or local conservation designations directly affected by the scheme. Downstream designations include Finn River SAC. The Protected species survey did note bat potential in some of the trees in close proximity to the embankments but mitigation should be possible. Score = -3* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Option Scoring		
Total Option Score	-2.0	*Potential localised loss or disturbance to the flora/fauna from embankments and floodwalls adjacent to the alignment of the old railway embankment. Upstream habitats in the storage area are yet to be assessed but the channel is poor and of low quality. Periodic wetting of this area is most likely to improve the natural habitat.*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*Whilst the water courses that could be directly impacted by the schemes are unclassified for fish habitat and are heavily polluted the River Finn SAC is directly downstream and Atlantic Salmon is a qualifying feature.*
Option Scoring		
Total Option Score	-4.0	*Atlantic Salmon as a qualifying feature of the Finn SAC could potentially be impacted through indirect effects as a result of the construction particularly sediment run-off and oils and chemicals impacting on the water quality in the downstream SAC (Score -5). Water quality is currently not adequate to support good ecological status which is required for Atlantic Salmon. Whilst the temporary construction impacts could have an impact on water quality there is an opportunity to reduce impacts from the WWTP during flood events which is a positive outcome of this option (Score = 1). Vibrational effects from the piling will also be considered as a potential impact and this can be mitigated through appropriate timing of the works.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the habitat in the area of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**-260**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The nature of the Finn Valley LCA, namely good quality agricultural riverine lands of semi-improved geometric fields, with scattered farms, farmsteads and one-off rural dwellings served by a number of rural villages and towns, means that there is greater capacity to assimilate additional development.*
Option Scoring		
Total Option Score	-1.0	*Earthen embankments constructed within the Finn Valley LCA will not have a significant permanent impact due to their location along existing railway embankments. They will not obstruct views from the town across the Finn Valley due to their location within low points in the topography. However there will be short term local impacts due to the visibility of construction sites within the LCA.*
Weighted Option Score	**-24**	*Global weighting x Local weighting x Total option score*

Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*A number of sites/features Recorded by NIAH are present and potentially affected with a moderate to low vulnerability*
Option Scoring		
Total Option Score	-1.0	*Changes to the setting of architectural features (NIAH) such that it is slightly changed.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*A number of sites listed on the RMP/RPS present and potentially affected. (high t0 moderate vulnerability)*
Option Scoring		
Total Option Score	-1.0	*The construction of a new flood embankment although outside of the zone of influence of Castle could change the character and setting slightly. All monuments are outside of flood extents so no additional protection is provided under this option.*
Weighted Option Score	**-12**	*Global weighting x Local weighting x Total option score*

Environmental Score	-54

Option Appraisal and the Multi-Criteria Analysis

Name of modeller	**Ryan Dodson**
Name of assessor	**Mark Wilson, Mark Magee, Niall Matthews**
Date of Assessment	**28/04/2022**
Option ID	**Option 3**
Option Type	Structural Option
Option Spatial Scale of Assessment (SSA)	Castlefinn
Option Details	Hard Defences (inc. CPI Wall) & Culvert Upgrades
AEP	1.0%
Option Cost	€8,184,442.00
Economic Benefit	€6,108,654.00

This MCA report should be read in conjunction with the OPW Technical Guidance Note - Option Appraisal and the Multi-Criteria Analysis Framework.

Multi-Criteria Analysis Summary

Castlefinn Option 3

1. Technical Criteria

Objective 1.A	Ensure flood risk management options are operationally robust	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Level of risk score	4	*No reliance on systems or intervention but some maintenance requirements*
Adjustment	No adjustment	*The level of risk score has not been adjusted*
Total Option Score	4.0	*Option score + adjustment*
Weighted Option Score	**400**	*Global weighting x Local weighting x Total option score*

Objective 1.B	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Option Score	2.0	*The following hazards have been identified: Working near water, Work which puts persons at risk of burial under earthfall., Heavey plant and machinery*
Adjustment	0.0	*There have been no adjustments made to the option score*
Total Option Score	2.0	*Option score + adjustment*
Weighted Option Score	**200**	*Global weighting x Local weighting x Total option score*

Objective 1.C	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	
Assigned Weightings		
Global Weighting	20.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Adaptability Score	3	*Option is adaptable at moderate cost*
Adjustment	No adjustment	*The adaptability score has not been adjusted*
Total Option Score	3.0	*Option score + adjustment*
Weighted Option Score	**300**	*Global weighting x Local weighting x Total option score*

Technical Score	900

Multi-Criteria Analysis Summary

Castlefinn Option 3

2. Economic Criteria

Objective 2.A	Reduce economic damages	
Assigned Weightings		
Global Weighting	24.0	*Nationally Constant Value*
Local Weighting	3.0	*AAD for the SSA / €75,000*
AAD for the SSA	€ 223,236.00	*Baseline Scenario*
Option Scoring		
Reduced AAD	€ 41,527.00	*Defended Scenario*
Total Option Score	4.1	*0.05 X Percentage Reduction in AAD*
Weighted Option Score	**291**	*Global weighting x Local weighting x Total option score*

Objective 2.B	Minimise risk to transport infrastructure	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	114.3	*Sum of factored scores for each transport infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	6.6	*Sum of factored scores for each transport infrastructure receptor at risk during defended scenario*
Option Score	4.7	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the option score*
Total Option Score	4.7	*Option score + adjustment*
Weighted Option Score	**236**	*Global weighting x Local weighting x Total option score*

Objective 2.C	Minimise risk to utility infrastructure	
Assigned Weightings		
Global Weighting	14.0	*Nationally Constant Value*
Local Weighting	163.5	*Sum of factored scores for each utility infrastructure receptor at risk during baseline scenario*
Capped Local Weighting	5.0	*1 ≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	4.3	*Sum of factored scores for each utility infrastructure receptor at risk during defended scenario*
Option Score	4.9	*5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Adjustment	No adjustment	*There has been no adjustment made to the total option score*
Total Option Score	4.9	*Option score + adjustment*
Weighted Option Score	**341**	*Global weighting x Local weighting x Total option score*

Objective 2.D	Manage risk to agriculture	
Assigned Weightings		
Global Weighting	12.0	*Nationally Constant Value*
Local Weighting	4.0	*Agricultural land downstream of Castlefinn is highly productive. Overall the agricultiral land around Castlefinn is considered good quality*
Option Scoring		
Total Option Score	0	*The River Finn flood defences will result in negligible changes to flood extent and depth upstream and downstream of Castlefinn.*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Economic Score	867

Multi-Criteria Analysis Summary

Castlefinn Option 3

3. Social Criteria

Objective 3.A (i)	Minimise risk to human health and life - Residents	
Assigned Weightings		
Global Weighting	27.0	*Nationally Constant Value*
Local Weighting	4.8	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No adjustment*
Capped Local Weighting	4.8	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.2	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**612**	*Global weighting x Local weighting x Total option score*

Objective 3.A (ii)	Minimise risk to human health and life - High vulnerability properties	
Assigned Weightings		
Global Weighting	17.0	*Nationally Constant Value*
Local Weighting	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	1.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.0	*Sum of the factored scores for all of the residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	0.0	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**0**	*Global weighting x Local weighting x Total option score*

Objective 3.B (i)	Minimise risk to community - Social Infrastructure and Amenity	
Assigned Weightings		
Global Weighting	9.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.5	*Sum of the factored scores for all of the social infrastructure and amenity assets at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Enhancement or Creation of Social Amenity Sites	0.0	*Adjustment in relation to the Enhancement or creation of social amenity sites (Structural Option)*
Total Option Score	4.5	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**203**	*Global weighting x Local weighting x Total option score*

Objective 3.B (ii)	Minimise risk to community - Local Employment	
Assigned Weightings		
Global Weighting	7.0	*Nationally Constant Value*
Local Weighting	5.0	*Sum of the factored scores for all of the non-residential properties at risk of flooding during baseline scenario*
Local Weighting Adjustment	0.0	*No Adjustment*
Capped Local Weighting	5.0	*1≤ capped local weight ≤ 5*
Option Scoring		
Residual Risk Score	0.4	*Sum of the factored scores for all of the non-residential properties at risk of flooding during defended scenario*
Residual Risk Score Adjustment	0.0	*No Adjustment*
Total Option Score	4.6	*Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]*
Weighted Option Score	**160**	*Global weighting x Local weighting x Total option score*

Social Score	974

Multi-Criteria Analysis Summary

Castlefinn Option 3

4. Environmental Criteria

Objective 4.A	Support the objectives of the WFD	
Assigned Weightings		
Global Weighting	16.0	*Nationally Constant Value*
Local Weighting	5.0	*Nationally Constant Value*
Option Scoring		
Total Option Score	2	*Hydromorphology - The water courses that will be affected by the scheme are very low grade and surveys have established that they are unclassified in terms of fisheries habitat and heavily polluted, including organic pollution from sewage and nutrients. The water courses are significantly altered and the culverts are sub standard. The scheme will not significantly impact on the hydromorphology of these watercourses and will result in an improvement in the existing culverts, however the absence of suitable fish habitat, the heavily polluted nature of the water courses mean that salmonids fish are not likely to use these water courses* *Biota - Short term impacts from construction could result in negative impacts from a physico- chemical perspective through the hydraulic pathways to the River Finn but this will be short term and can be mitigated. Vibration impacts from piling can impact on migratory Atlantic Salmon which can also have an impact but this can be mitigated through appropriate timing of the works etc. (Score = -2)* *Physico- chemical - WWTP is at risk of flooding and surveys have identified sewage as a particularly pressure on the Bridge Burn Water Course as well as septic tanks. The protection of the WWTP will reduce the pollution during flood events and therefore is a positive (Score = 4).*
Weighted Option Score	**160**	*Global weighting x Local weighting x Total option score*

Objective 4.B	Support the objectives of the Habitats and Birds Directives	
Assigned Weightings		
Global Weighting	10.0	*Nationally Constant Value*
Local Weighting	4.0	*River Finn SAC immediately downstream and is hydrologically connected.*
Option Scoring		
Total Option Score	1	*Evidence of otter activity was noted during field surveys along the banks of the River Finn but remote from this option. The other Qualifying Feature that could potentially be impacted is Atlantic Salmon and indirect effects as a result of the construction particularly sediment run-off and oils and chemicals could impact on the water quality in the downstream SAC . The extent of the embankment works is less given that the larger defences at the CPI centre will remove the need for the earthen flood defence downstream, therefore this scores marginally better that option 1 (Score -4). Whilst the temporary construction impacts could have an impact on water quality there there will be a significant benefit in terms of eliminating sources of flood event pollution runoff incidents by protection the WWTP and properties which is a positive outcome of this option (Score = 4). Vibrational effects from the piling will also be considered as a potential impact and this can be mitigated through appropriate timing of the works.* *Protected Species Surveys noted that there was some potential for bat (Annex I roosts in a number of trees within the study area, however all options will result in a similar impact in terms of Bats and suitable mitigation will be possible. No otter activity was noted in the works area.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**40**	*Global weighting x Local weighting x Total option score*

Objective 4.C	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	
Assigned Weightings		
Global Weighting	5.0	*Nationally Constant Value*
Local Weighting	3.0	*The riparian zone of the Castlefinn River is not particularly sensitive and with improved grassland being dominant habitat there is some wet grassland, freshwater swamp and woodlands near the location of the proposed embankments but these are unlikely to be impacted directly, although some tree felling may be required for access. There are no areas of national regional or local conservation designations directly affected by the scheme. Downstream designations include Finn River SAC.*
Option Scoring		
Total Option Score	-2.0	*Potential localised loss or disturbance to the flora/fauna from embankments and floodwalls adjacent to the alignment of the old railway embankment. Score would be slightly better that option 1 and 3 due to less potential to impact on the woodland and wet swamp at the CPI embankment however more extensive walled embankments and piling around CPI centre offsets this.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the flora of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**-30**	*Global weighting x Local weighting x Total option score*

Objective 4.D	Protect and where possible enhance fisheries resource within the catchment (Inland Fisheries Only)	
Assigned Weightings		
Global Weighting	13.0	*Nationally Constant Value*
Local Weighting	5.0	*Whilst the water courses that could be directly impacted by the schemes are unclassified for fish habitat and are heavily polluted the River Finn SAC is directly downstream and Atlantic Salmon is a qualifying feature.*
Option Scoring		
Total Option Score	-4.0	*Atlantic Salmon as a qualifying feature of the Finn SAC could potentially be impacted through indirect effects as a result of the construction particularly sediment run-off and oils and chemicals impacting on the water quality in the downstream SAC (Score -5). Water quality is currently not adequate to support good ecological status which is required for Atlantic Salmon. Whilst the temporary construction impacts could have an impact on water quality there is an opportunity to reduce impacts from the WWTP during flood events which is a positive outcome of this option (Score = 1). Vibrational effects from the piling will also be considered as a potential impact and this can be mitigated through appropriate timing of the works.* *There is extensive infestation with Invasive Alien Species along the alignment of the embankment the scheme will address these pressures through the application of the ISMP. This will result in an improvement to the habitat in the area of the area and therefore a positive score (Score = 1)*
Weighted Option Score	**-260**	*Global weighting x Local weighting x Total option score*

Objective 4.E	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence	
Assigned Weightings		
Global Weighting	8.0	*Nationally Constant Value*
Local Weighting	3.0	*The nature of the Finn Valley LCA, namely good quality agricultural riverine lands of semi-improved geometric fields, with scattered farms, farmsteads and one-off rural dwellings served by a number of rural villages and towns, means that there is greater capacity to assimilate additional development.*
Option Scoring		
Total Option Score	-2.0	*Earthen embankment constructed within the Finn Valley LCA will not have a significant permanent impact due to location along existing railway embankment in the west of the town. It will not obstruct views from the town across the Finn Valley due to the location within low point in the topography. However there will be short term local impacts due to the visibility of the construction site within the LCA. Walls around the CPI centre may be more visible from the N15 although there is some good screening. Option is scored down due to the more intrusive nature of the defences but still considered short term (construction) impact with the potential finished walls not impacting any views across the LCA.*
Weighted Option Score	**-48**	*Global weighting x Local weighting x Total option score*

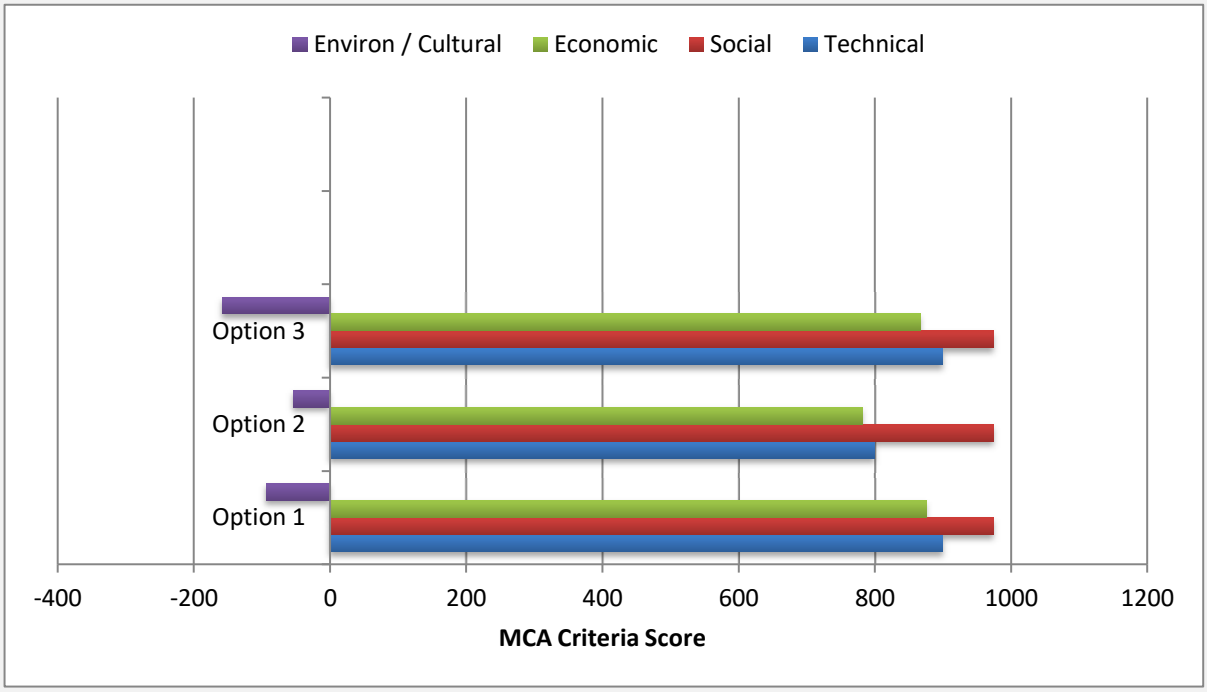
Objective 4.F (i)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	2.0	*A number of sites/features Recorded by NIAH are present and potentially affected with a moderate to low vulnerability*
Option Scoring		
Total Option Score	-1.0	*Changes to the setting of architectural features (NIAH) such that it is slightly changed.*
Weighted Option Score	**-8**	*Global weighting x Local weighting x Total option score*

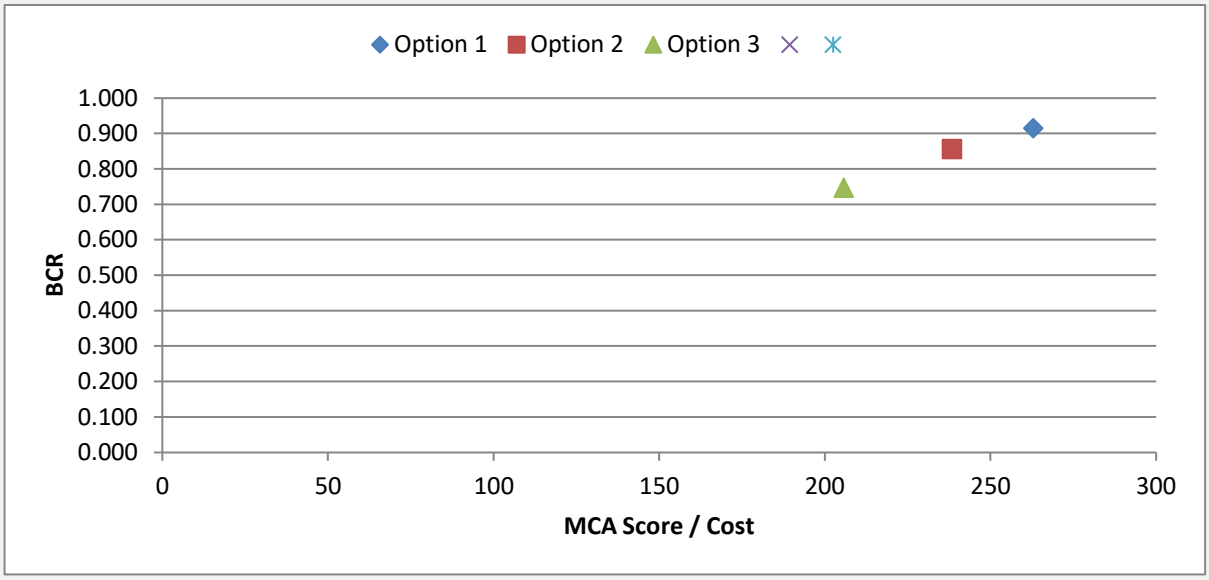
Objective 4.F (ii)	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.	
Assigned Weightings		
Global Weighting	4.0	*Nationally Constant Value*
Local Weighting	3.0	*A number of sites listed on the RMP/RPS present and potentially affected. (high t0 moderate vulnerability)*
Option Scoring		
Total Option Score	-1.0	*The construction of a new flood embankment although outside of the zone of influence of Castle could change the character and setting slightly. All monuments are outside of flood extents so no additional protection is provided under this option.*
Weighted Option Score	**-12**	*Global weighting x Local weighting x Total option score*

Environmental Score	-158

Option Comparison
Castlefinn

Option No.	MCA Appraisal Scores				TOTAL - MCA Benefit Score	Cost (€millions)	MCA Score / Cost	BCR
	Technical	Social	Economic	Environ / Cultural				
Option 1	900	974	875	-94	1756	6.678	262.882	0.915
Option 2	800	974	781	-54	1701	7.139	238.298	0.856
Option 3	900	974	867	-158	1683	8.184	205.686	0.746





Appendix E

Costing sheets

Option 1 Description - Castlefinn

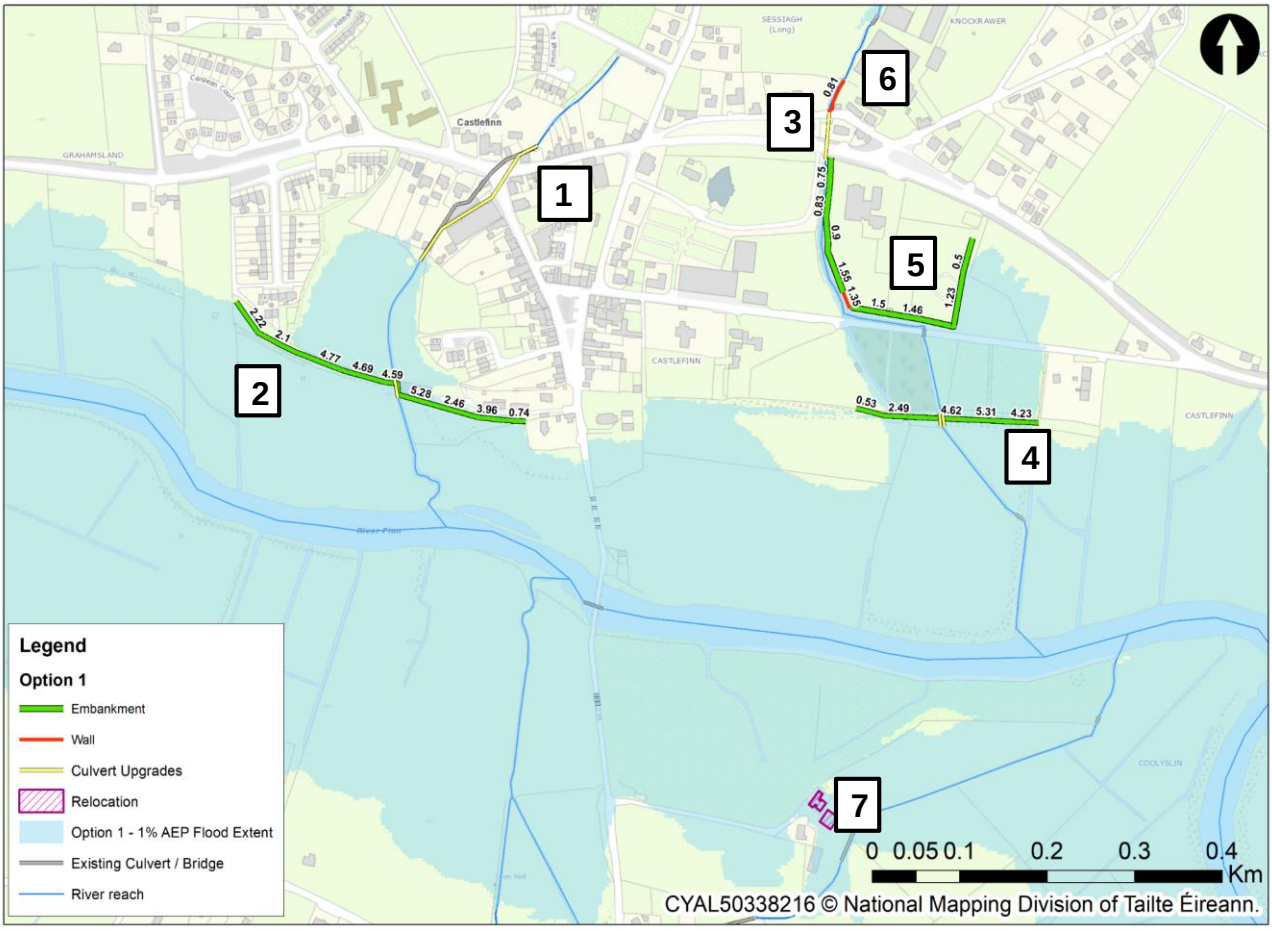
Shortlisted measures

The following measures have been shortlisted through option screening process for the Castlefinn FRS. These measures can be combined to provide flood scheme providing the design SoP.
Measures have been grouped into three areas. The Bridge Burn Stream area, the Castlefinn WC area and the Corcullion Stream area.

List of elements

Bridge Burn	Castlefinn WC	Corcullion
1. Culvert upgrade	3. Culvert upgrade	7. Property Relocation
2. Flood embankment	4. Flood embankment	
	5. CPI bund	
	6. Flood Wall	

Sketch of Option



Element 1 Construction Costs

Bridge Burn Area - Culvert upgrade

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	190	m
Culvert diameter	1.2	m
Manholes	4	no.

Clashes

Category	Type	Description	Quantity
Utility	Sewer	IW Combined	60.00
Utility	Electricity & telephone OH	EIR fibre optic	60.00
Utility	Watermain	IW Watermain	60.00
Infrastructure	National road crossing		
Infrastructure	Buildings adjacent		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.00	no.	€15,000	Prev. Job	€15,000
2	Site clearance (fences, street furniture)	0.95	ha	€14,000	Prev. Job	€13,300
3	Cold Milling	190	m	€1.50	Prev. Job	€285
4	Water main diversion	60	m	€1,500	Prev. Job	€90,000
5	Sewer diversion	60	m	€1,000	Prev. Job	€60,000
6	Fibre Optic diversion	60	m	€3,000	Prev. Job	€180,000
7	Electric pole move	1	no.	€10,000	Prev. Job	€10,000
8	Demolish shed	1	no.	€10,000	Prev. Job	€10,000
9	Culvert t (1.2m dia) - inc excavation, supports and backfilling. Up to 3.5m deep, extensive constraints.	190	m	€1,020	Prev. Job	€193,800
10	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
11	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
12	Manhole - inc excavation, supports and backfilling	4	no.	€2,000	SPONS 2022	€8,000
13	45mm Hot Rolled Asphalt, HRA 35/14F Surface Course	570	m²	€45.74	SPONS 2022	€26,069.12
14	Binder Course Cold Milling	570	m²	€2.00	Prev. Job	€1,140
15	55mm Asphalt Concrete, AC20 DBM Binder Course	570	m²	€32.28	SPONS 2022	€18,401
16	100mm Asphalt Concrete, AC32 DBM Base	570	m²	€43.62	SPONS 2022	€24,861
17	350mm Type 3 Granular Sub Base	570	m²	€22.40	Prev. Job	€12,768

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
18	250mm Capping Layer	570	m²	€21.33	Prev. Job	€12,158
19	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000
20	Construct shed	1	no.	€30,000	Prev. Job	€30,000
				Total construction cost		€745,783

Element 2 Construction Costs

Bridge Burn Area - Earth Embankment

Quantities generated from GIS modelling and assumed embankment cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	14,483	m³
Clay core Volume	6,615	m³
Cutoff Volume	375	m³
Footprint Area	6,840	m²
Surface Area	7,170	m²
Length	375	m
Max Height	6.19	m
Volume of old embankment (reused)	4101	m³

Clashes

Category	Type	Decsription	Quantity
Utility	Electricity OH cables		
Utility	WwTW		
Environmental	Invasive species		
Infrastructure	Electricity OH cables		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	1.86	acre	€15,000	Prev. Job	€27,876
2	Clearance - Vegetation killing	0.75	ha	€230	Prev. Job	€173
3	Clearance - Invasive species	0.75	ha	€5,000	Prev. Job	€3,762
4	Clearance - trees	50	no.	€90	Prev. Job	€4,500
5	Clearance - Site clearance & disposal	0.75	ha	€14,000	Prev. Job	€10,534
6	Excavation - Topsoil strip & stockpile	2257	m³	€8	Prev. Job	€18,058
7	Excavation - Cutting (inc old embankment)	375	m³	€5	Prev. Job	€1,886
8	Disposal - Cutting (inc old embankment)	375	m³	€26	Prev. Job	€9,615
9	Filling - Provision of topsoil	2151	m³	€30	Prev. Job	€64,530
10	Filling - Topsoil (300mm depth)	2151	m³	€9	Prev. Job	€18,284
11	Filling - Provision of clay fill	6615	m³	€35	Prev. Job	€231,525
12	Filling - Placing of clay fill	6615	m³	€15	Prev. Job	€99,225
13	Filling - Provision of outer fill	3767	m³	€25	Prev. Job	€94,175
14	Filling - Placing of outer fill	7868	m³	€10	Prev. Job	€78,680
15	Geotextile mat	7170	m²	€4	Prev. Job	€28,680
16	Finishing - Grassing out	7887	m²	€1	Prev. Job	€8,281
17	Culvert through embankment (1.2m dia) - inc excavation, supports and backfilling	31	m	€510	Prev. Job	€15,810

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
18	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
19	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
20	Flap valve	1	no.	€10,000	Prev. Job	€10,000
21	Haul Road	225	m²	€180	Prev. Job x 2	€40,500
22	Drainage	375	m	€35	Prev. Job	€13,125
					Total construction cost	€809,219

Element 3 Construction Costs

Castlefinn Area - Culvert upgrade

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	55	m
Culvert diameter	1.3	m
Manholes	1	no.

Clashes

Category	Type	Decription	Quantity
Utility	Sewer	IW Combined	30.00
Utility	Electricity & telephone OH	EIR fibre optic	30.00
Utility	Watermain	Iw Watermain	30.00
Infrastructure	National road crossing		
Infrastructure	Minor road crossing		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.00	no.	€10,000	Prev. Job	€10,000
2	Site clearance (fences, street furniture)	0.28	ha	€14,000	Prev. Job	€3,850
3	Cold Milling	25	m	€1.50	Prev. Job	€38
4	Water main diversion	30	m	€1,500	Prev. Job	€45,000
5	Sewer diversion	30	m	€1,000	Prev. Job	€30,000
6	Fibre Optic diversion	30	m	€3,000	Prev. Job	€90,000
7	Sewer pump station disruption	1	no.	€10,000	Prev. Job	€10,000
8	Culvert (1.35m dia) - inc excavation, supports and backfilling, 2.5m deep.	55	m	€510	Prev. Job	€28,050
9	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
10	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
11	Manhole - inc excavation, supports and backfilling	1	no.	€2,000	SPONS 2022	€2,000
12	45mm Hot Rolled Asphalt, HRA 35/14F Surface Course	75	m²	€45.74	SPONS 2022	€3,430
13	Binder Course Cold Milling	75	m²	€2.00	Prev. Job	€150
14	55mm Asphalt Concrete, AC20 DBM Binder Course	75	m²	€32.28	SPONS 2022	€2,421
15	100mm Asphalt Concrete, AC32 DBM Base	75	m²	€43.62	SPONS 2022	€3,271
16	350mm Type 3 Granular Sub Base	75	m²	€22.40	Prev. Job	€1,680
17	250mm Capping Layer	75	item	€21.33	Prev. Job	€1,600
18	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000

Total construction cost **€271.490**

Element 4 Construction Costs

Castlefinn Area - Earth Embankment

Quantities generated from GIS modelling and assumed embankment cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	10,179	m³
Clay core Volume	4,445	m³
Cutoff Volume	210	m³
Footprint Area	4,525	m²
Surface Area	4,747	m²
Length	210	m
Max Height	5.23	m
Volume of old embankment (reused)	9404	m³

Clashes

Category	Type	Description	Quantity
Utility	Not known		
Environmental	Invasive species		
Infrastructure	None identified		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	1.23	acre	€15,000	Prev. Job	€18,442
2	Clearance - Vegetation killing	0.50	ha	€230	Prev. Job	€114
3	Clearance - Invasive species	0.50	ha	€5,000	Prev. Job	€2,489
4	Clearance - trees	50.0	no.	€90	Prev. Job	€4,500
5	Clearance - Site clearance & disposal	0.50	ha	€14,000	Prev. Job	€6,969
6	Excavation - Topsoil strip & stockpile	1493	m³	€8	Prev. Job	€11,946
7	Excavation - Cutting (inc old embankment)	210	m³	€5	Prev. Job	€1,056
8	Disposal - Cutting (inc old embankment)	210	m³	€26	Prev. Job	€5,384
9	Filling - Provision of topsoil	1424	m³	€30	Prev. Job	€42,723
10	Filling - Topsoil (300mm depth)	1424	m³	€9	Prev. Job	€12,105
11	Filling - Provision of clay fill	4445	m³	€35	Prev. Job	€155,575
12	Filling - Placing of clay fill	4445	m³	€15	Prev. Job	€66,675
13	Filling - Provision of outer fill	0	m³	€25	Prev. Job	€0
14	Filling - Placing of outer fill	5734	m³	€10	Prev. Job	€57,340
15	Geotextile mat	4747	m²	€4	Prev. Job	€18,988
16	Finishing - Grassing out	5222	m²	€1	Prev. Job	€5,483
17	Culvert through embankment (1.0 x 1.5m box) - inc excavation, supports and backfilling	62	m	€510	Prev. Job	€31,620
18	Headwall and outlet	4	no.	€10,000	Prev. Job	€40,000

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
19	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
20	Flap valve	1	no.	€10,000	Prev. Job	€10,000
21	Haul Road	540	m²	€90	Prev. Job	€48,600
22	Drainage	210	m	€35	Prev. Job	€7,350
					Total construction cost	€557,359

Element 5 Construction Costs

Castlefinn Area - CPI bund

Quantities generated from GIS modelling and assumed embankment/wall cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	2,710	m^3
Clay core Volume	1,860	m^3
Cutoff Volume	400	m^3
Footprint Area	3,033	m^2
Surface Area	3,205	m^2
Length	400	m^2
Max Height	1.60	m

Clashes

Category	Type	Description	Quantity
Utility	Not known		
Environmental	Invasive species		
Infrastructure	None identified		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1.	Land compensation	0.82	acre	€15,000	Prev. Job	€12,361
2.	Clearance - Vegetation killing	0.33	ha	€230	Prev. Job	€77
3.	Clearance - Invasive species	0.33	ha	€5,000	Prev. Job	€1,668
4.	Clearance - Site clearance & disposal	0.33	ha	€14,000	Prev. Job	€4,671
5.	Excavation - Topsoil strip & stockpile	1001	m^3	€8	Prev. Job	€8,007
6.	Excavation - Cutting	400	m^3	€5	Prev. Job	€2,012
7.	Disposal - Cutting	400	m^3	€26	Prev. Job	€10,256
8.	Filling - Provision of topsoil	962	m^3	€30	Prev. Job	€28,845
9.	Filling - Topsoil (300mm depth)	962	m^3	€9	Prev. Job	€8,173
10.	Filling - Provision of clay fill	1860	m^3	€35	Prev. Job	€65,100
11.	Filling - Placing of clay fill	1860	m^3	€15	Prev. Job	€27,900
12.	Filling - Provision of outer fill	850	m^3	€25	Prev. Job	€21,250
13.	Filling - Placing of outer fill	850	m^3	€10	Prev. Job	€8,500
14.	Geotextile mat	3205	m^2	€4	Prev. Job	€12,820
15.	Finishing - Grassing out	3526	m^2	€1	Prev. Job	€3,702
16.	Drainage	400	m	€35	Prev. Job	€14,000
16.	Garden Reinstatement	180	m^2	€140	Prev. Job	€25,200
					Total construction cost	€254,541

Element 6 Construction Costs

Wall Upstream of N15 on Castlefinn Watercourse (inc. wall section at CPI)

Quantities generated from GIS modelling and assumed wall makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

1	Working Area	739	m²
2	Footprint	117	m²
3	Base Volume	47	m³
4	Stem Volume	37	m³
5	Stem Face	92	m²
6	Exposed Stem Face	61	m²
7	Length	62.22	m²

Clashes

Item	Category	Type	Description	Quantity
1	Utility	Not known		
2	Environmental	Invasive species		
3	Infrastructure	None identified		
4	Land use	Not known		
5	Land access	Not known		
6	Ground contamination	Not known		
7	Soil conditions	Not known		

Cost Breakdown

Item	Description	Quantity	Unit	Rate	Source	Total
1	Clearance - Vegetation killing	0.074	ha	230.00	Prev. Job	17.00
2	Clearance - Site clearance & disposal	0.074	ha	14,000.00	Prev. Job	1,034.60
3	Excavation - Topsoil strip & stockpile	739	m3	3.00	Prev. Job	2,217.00
4	Excavation - Cutting	117	m3	5.03	Prev. Job	589.52
5	Disposal - Cutting	117	m3	25.64	Prev. Job	3,005.01
6	Base Slab - Concrete	47	m3	200.00	Prev. Job	9,376.00
7	Base Slab - Reinforcement	4	t	1,500.00	Prev. Job	5,555.28
8	Base Slab - Trench fill	12	m3	150.00	Prev. Job	1,758.00
9	Base Slab - Formwork	25	m3	100.00	Prev. Job	2,488.80
10	Wall - Concrete	37	m3	200.00	Prev. Job	7,384.00
11	Wall - Reinforcement	3	t	1,500.00	Prev. Job	4,375.02
12	Wall - Formwork	185	m2	100.00	Prev. Job	18,462.00
13	Wall - Finish (Granite)	122	m2	80.00	Prev. Job	9,792.00
14	Drainage	62	m	70.00	Prev. Job	4,355.40
					Total construction cost	**€70,409.62**

Element 7 Construction Costs

Property relocation

Quantities generated from GIS property counts. Rates generated from current market data for similar property types and from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Number of properties	1	no.
Size of house	350	m3

Clashes

Category	Type	Description	Quantity
Utility	general services		1.0
Infrastructure	None identified		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	New houses	1.0	no.	€ 141,918.00	Data for similar properties from sales register on www.daft.ie	€141,918
2	Outbuildings	1.0	no.	€81,894		€81,894
3	Relocation costs and administration	1.0	no.	30%	Data	€67,144
4	Demolition of buildings	800	m3	€17	Prev. Job	€13,840
5	Decommisioning of services	1	no.	€10,000	Prev. Job	€10,000
				Total construction cost		**€314,796**

Operation and Maintenance

The various elements of this option will have associated operation and maintenance (O&M) costs. Costs are dependant on the responsible body (eg local authority, government body, private party), the complexity of the element (eg moving parts, high precision tolerances), and the robustness of the element (eg rate of degradation, risk of collapse).

Bridge Burn Area - Culvert upgrade

Annual O&M cost	€	582
Assumptions	Cost based on a rate of €582/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Bridge Burn Area - Earth Embankment

Annual O&M cost	€	1,022
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Castlefinn Area - Culvert upgrade

Annual O&M cost	€	472
Assumptions	Cost based on a rate of €472/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Castlefinn Area - Earth Embankment

Annual O&M cost	€	572
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Castlefinn Area - CPI bund

Annual O&M cost	€	1,090
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Wall Upstream of N15 on Castlefinn Watercourse (inc. wall section at CPI)

Annual O&M cost	€	31
Assumptions	Cost based on a rate of €0.5/m/year. Maintenance includes for vegetation control, inspections.	

Total O&M Annual Costs

O&M costs per year	**€**	**3,769**

Whole Life Cost

Design Life

Bridge Burn Area - Culvert upgrade	50yrs
Bridge Burn Area - Earth Embankment	50yrs
Castlefinn Area - Culvert upgrade	50yrs
Castlefinn Area - Earth Embankment	50yrs
Castlefinn Area - CPI bund	50yrs
Wall Upstream of N15 on Castlefinn Watercourse (inc. wall section at CPI)	50yrs
Property relocation	50yrs

Financial Assumptions

Financial period	50yrs
Discount rate	4%

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
0	1.000			-	-
1	0.962	3,023,596		2,907,304	-
2	0.925		3,769	-	3,485
3	0.889		3,769	-	3,351
4	0.855		3,769	-	3,222
5	0.822		3,769	-	3,098
6	0.790		3,769	-	2,979
7	0.760		3,769	-	2,864
8	0.731		3,769	-	2,754
9	0.703		3,769	-	2,648
10	0.676		3,769	-	2,546
11	0.650		3,769	-	2,448
12	0.625		3,769	-	2,354
13	0.601		3,769	-	2,264
14	0.577		3,769	-	2,177
15	0.555		3,769	-	2,093
16	0.534		3,769	-	2,012
17	0.513		3,769	-	1,935
18	0.494		3,769	-	1,861
19	0.475		3,769	-	1,789
20	0.456		3,769	-	1,720
21	0.439		3,769	-	1,654
22	0.422		3,769	-	1,590
23	0.406		3,769	-	1,529
24	0.390		3,769	-	1,470
25	0.375		3,769	-	1,414
26	0.361		3,769	-	1,360
27	0.347		3,769	-	1,307
28	0.333		3,769	-	1,257
29	0.321		3,769	-	1,209
30	0.308		3,769	-	1,162
31	0.296		3,769	-	1,117
32	0.285		3,769	-	1,074
33	0.274		3,769	-	1,033
34	0.264		3,769	-	993
35	0.253		3,769	-	955
36	0.244		3,769	-	918
37	0.234		3,769	-	883
38	0.225		3,769	-	849
39	0.217		3,769	-	816
40	0.208		3,769	-	785
41	0.200		3,769	-	755
42	0.193		3,769	-	726

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
43	0.185		3,769	-	698
44	0.178		3,769	-	671
45	0.171		3,769	-	645
46	0.165		3,769	-	620
47	0.158		3,769	-	597
48	0.152		3,769	-	574
49	0.146		3,769	-	552
50	0.141		3,769	-	530
				€ 2,907,304	**€ 77,347**

Optimism Bias

The starting (upper bound) Optimism Bias for strategy costs (pre-feasibility stage) is 60%. The Optimism Bias (OB) consists of risk components. Each risk component contributes a pre-defined percentage of overall OB factor. These risk components can be reduced for individual strategies or schemes if demonstrable action to minimise risks has been taken, or other evidence provided that risks are not applicable to the degree indicated. In which case the revised sum of risk components should be divided by 100 and multiplied by 60 to obtain the new OB factor.

Risk Component		Definition	%	Adjustment comment	Adj %
Procurement	Late contractor involvement in design	Late involvement of the contractor in the design leads to redesign or problems during construction	1	No adjustment	1
	Dispute and claims occurred	Disputes and claims occur where no mechanisms exist to manage effectively adversarial relationships between project stakeholders	11	**Contract will provide a suitable mechanism to address disputes and claims**	**5**
	Other	Other factors that relate to procurement which affect the final project cost	1	No adjustment	1
Project-specific	Design complexity	The complexity of design (including requirements, specifications and detailed design) requires significant management, impacting on final project costs	4	**Design is not considered overly complex and is accounted for as an individual item in the option summary**	**2**
	Degree of innovation	The degree of innovation required due to the nature of the project requires unproven methods to be used	4	**No unproven methods being used**	**1**
	Environmental impact	The project has a major impact on its adjacent area leading to objection from neighbours and the general public	13	**Environmental contraints have been considered at optioneering stage. No major constraints identified**	**6**
	Other	Other project-specific factors which affect the final project cost	9	No adjustment	9
Client specific	Inadequacy of Business Case	The project scope changes as a result of the poor quality of requirement specifications and inadequate project scope definition	23	**An extensive project scope is being used with an established business case model. While risk remains it can be reduced.**	**12**
	Funding availability	Project delays or changes in scope occur as a result of the availability of funding (e.g. departmental budget spent or insufficient contingency funds)	2	No adjustment	2
	Project management team	The project management team's capabilities and/or experience impact on final project costs	1	No adjustment	1

	Poor project intelligence	The quality of initial project intelligence (e.g. preliminary site investigation, user requirements surveys etc.) impacts on the occurrence of unforeseen problems and costs	8	No adjustment	8
Environment	Public relations	A high level of effort is required to address public concern about the project, which impacts on the final project cost	5	**Engagement has already occurred to inform public of project. They are broadly supportive.**	**3**
	Site characteristics	The characteristics of the proposed environment for the project are highly sensitive to the project's environmental impacts (e.g. Greenfield site with badger setts, or contaminated brownfield site)	4	No adjustment	4
External influences	Economic	The project costs are sensitive to economic influences such as higher-than-expected construction cost inflation, oil price shocks etc.	5	**It is likely that project costs will be affected by construction cost inflation and oil price increases.**	**20**
	Legislation/regulations	The project costs are sensitive to legislation and regulation changes, e.g. health and safety and building regulations	4	No adjustment	4
	Technology	The project costs are sensitive to technological advancements, e.g. the effects of obsolescence.	4	**It is not expected that the project will be sensitive to technological advancements, constructions methods are well established.**	**2**
	Other	Other external influencing factors which affect the final project cost	1	No adjustment	1
		TOTAL	100	TOTAL	82
Optimism Bias -		**Upper Bound**	**60**	**Adjusted**	**49.2**

Option 1 Summary

PV Construction Costs (year 1)				**€2,907,304**
Bridge Burn Area - Culvert upgrade	€717,099			
Bridge Burn Area - Earth Embankment	€778,095			
Castlefinn Area - Culvert upgrade	€261,048			
Castlefinn Area - Earth Embankment	€535,922			
Castlefinn Area - CPI bund	€244,751			
Wall Upstream of N15 on Castlefinn Watercourse (inc. wall section at CPI)	€67,702			
Basic Construction Cost (BCC)	**€2,604,616**			
Property relocation	€302,688			
Preliminary Costs		15.15% of BCC	€ 394,660	
Ground Investigation		5% of BCC	€ 145,365	
Overall construction cost (OCC)				**€ 3,447,329**
Design & Envronmental Fees		8.6% of OCC	€ 296,470	
Site Supervision Fees		8% of OCC	€ 275,786	
	Total Fees		€ 572,257	
Archaeology & Environmental Mitigation		10% of OCC	€ 344,733	
Percent for Art		1% of OCC	€ 34,473	
PV Operation and Maintenance Costs (50yrs)			€ 77,347	
	Total		€ 456,553	
Sub-total				**€ 4,476,139**
Optimism Bias		49%	€ 2,202,261	
Total Cost				**€ 6,678,400**

Option 2 Description - Castlefinn

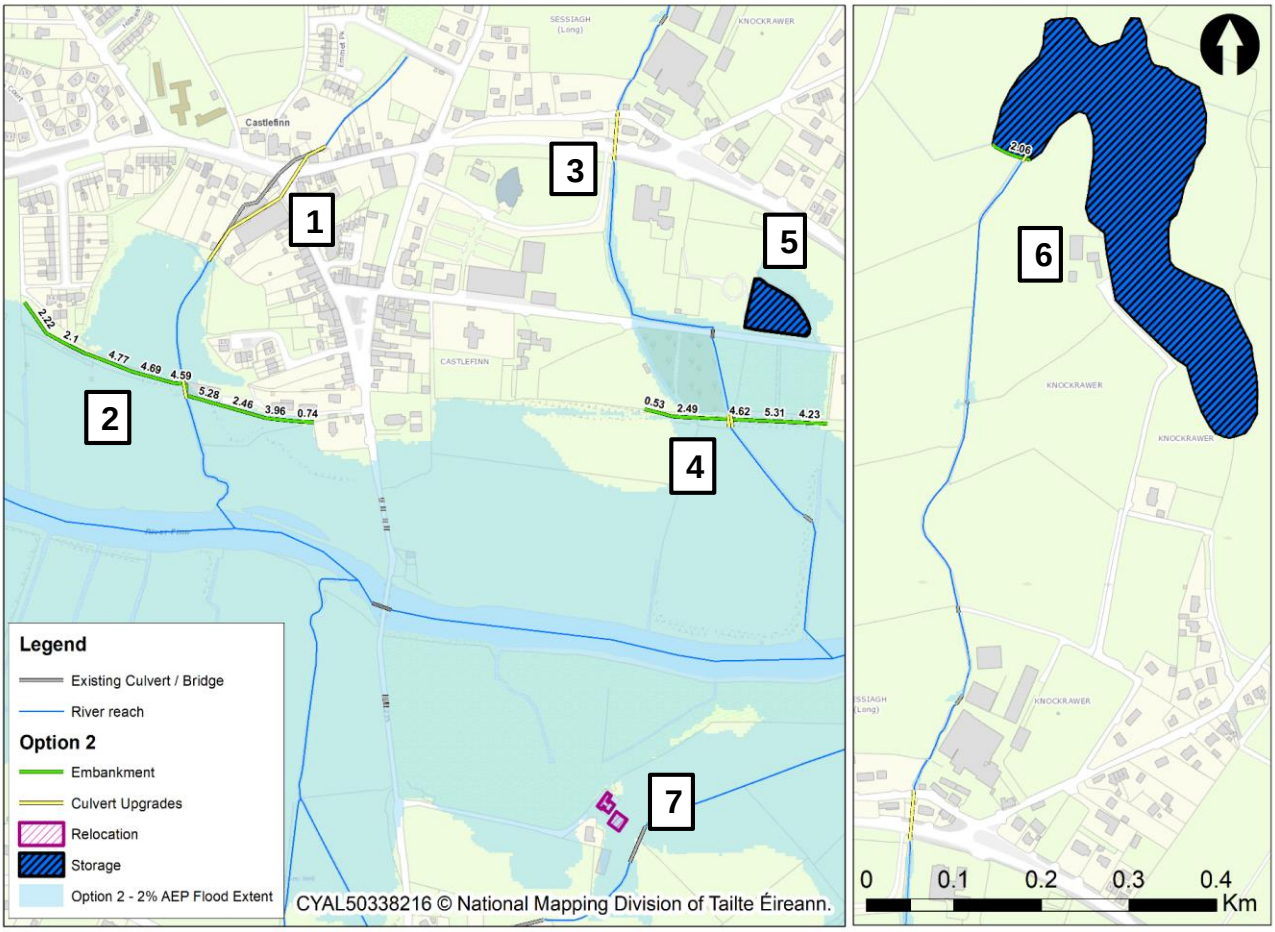
Shortlisted measures

The following measures have been shortlisted through option screening process for the Castlefinn FRS. These measures can be combined to provide flood scheme providing the design SoP.
Measures have been grouped into three areas. The Bridge Burn Stream area, the Castlefinn WC area and the Corcullion Stream area.

List of elements

Bridge Burn	Castlefinn WC	Corcullion
1. Culvert upgrade	3. Culvert upgrade	7. Property Relocation
2. Flood embankment	4. Flood embankment	
	5. Flood Storage (CPI)	
	6. Flood Storage (Upstream)	

Sketch of Option



Element 1 Construction Costs

Bridge Burn Area - Culvert upgrade

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	190	m
Culvert diameter	1.2	m
Manholes	4	no.

Clashes

Category	Type	Description	Quantity
Utility	Sewer	IW Combined	60.00
Utility	Electricity & telephone OH	EIR fibre optic	60.00
Utility	Watermain	Iw Watermai	60.00
Infrastructure	National road crossing		
Infrastructure	Buildings adjacent		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.00	no.	€15,000	Prev. Job	€15,000
2	Site clearance (fences, street furniture)	0.95	ha	€14,000	Prev. Job	€13,300
3	Cold Milling	190	m	€1.50	Prev. Job	€285
4	Water main diversion	60	m	€1,500	Prev. Job	€90,000
5	Sewer diversion	60	m	€1,000	Prev. Job	€60,000
6	Fibre Optic diversion	60	m	€3,000	Prev. Job	€180,000
7	Electric pole move	1	no.	€10,000	Prev. Job	€10,000
8	Demolish shed	1	no.	€10,000	Prev. Job	€10,000
9	Culvert t (1.2m dia) - inc excavation, supports and backfilling. Up to 3.5m deep, extensive constraints.	190	m	€1,020	Prev. Job	€193,800
10	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
11	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
12	Manhole - inc excavation, supports and backfilling	4	no.	€2,000	SPONS 2022	€8,000
13	45mm Hot Rolled Asphalt, HRA 35/14F Surface Course	570	m²	€45.74	SPONS 2022	€ 26,069.12
14	Binder Course Cold Milling	570	m²	€2.00	Prev. Job	€1,140
15	55mm Asphalt Concrete, AC20 DBM Binder Course	570	m²	€32.28	SPONS 2022	€18,401
16	100mm Asphalt Concrete, AC32 DBM Base	570	m²	€43.62	SPONS 2022	€24,861

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
17	350mm Type 3 Granular Sub Base	570	m²	€22.40	Prev. Job	€12,768
18	250mm Capping Layer	570	m^2	€21.33	Prev. Job	€12,158
19	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000
20	Construct shed	1	no.	€30,000	Prev. Job	€30,000
					Total construction cost	€745,783

Element 2 Construction Costs

Bridge Burn Area - Earth Embankment

Quantities generated from GIS modelling and assumed embankment cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	14,483	m³
Clay core Volume	6,615	m³
Cutoff Volume	375	m³
Footprint Area	6,840	m²
Surface Area	7,170	m²
Length	375	m
Max Height	6.19	m
Volume of old embankment (reused)	4104	m³

Clashes

Category	Type	Description	Quantity
Utility	Electricity OH cables		
Utility	WwTW		
Environmental	Invasive species		
Infrastructure	Electricity OH cables		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	1.86	acre	€15,000	Prev. Job	€27,876
2	Clearance - Vegetation killing	0.75	ha	€230	Prev. Job	€173
3	Clearance - Invasive species	0.75	ha	€5,000	Prev. Job	€3,762
4	Clearance - trees	50	no.	€90	Prev. Job	€4,500
5	Clearance - Site clearance & disposal	0.75	ha	€14,000	Prev. Job	€10,534
6	Excavation - Topsoil strip & stockpile	2257	m³	€8	Prev. Job	€18,058
7	Excavation - Cutting (inc old embankment)	375	m³	€5	Prev. Job	€1,886
8	Disposal - Cutting (inc old embankment)	375	m³	€26	Prev. Job	€9,615
9	Filling - Provision of topsoil	2151	m³	€30	Prev. Job	€64,530
10	Filling - Topsoil (300mm depth)	2151	m³	€9	Prev. Job	€18,284
11	Filling - Provision of clay fill	6615	m³	€35	Prev. Job	€231,525
12	Filling - Placing of clay fill	6615	m³	€15	Prev. Job	€99,225
13	Filling - Provision of outer fill	3764	m³	€25	Prev. Job	€94,100
14	Filling - Placing of outer fill	7868	m³	€10	Prev. Job	€78,680
15	Geotextile mat	7170	m²	€4	Prev. Job	€28,680
16	Finishing - Grassing out	7887	m²	€1	Prev. Job	€8,281
17	Culvert through embankment (1.2m dia) - inc excavation, supports and	31	m	€510	Prev. Job	€15,810
18	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
19	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
20	Flap valve	1	no.	€10,000	Prev. Job	€10,000
21	Haul Road	225	m²	€180	Prev. Job x 2	€40,500
22	Drainage	375	m	€35	Prev. Job	€13,125
					Total construction cost	€809,144

Element 3 Construction Costs

Castlefinn Area - Culvert upgrade (Reduced)

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	30	m
Culvert diameter	0.9	m
Manholes	2	no.

Clashes

Category	Type	Description	Quantity
Utility	Sewer	IW Combined	30.00
Utility	Watermain	IW Watermain	30.00
Utility	Pumping station		
Infrastructure	National road crossing		
Infrastructure	Minor road crossing		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.00	no.	€8,000	Prev. Job	€8,000
2	Site clearance (fences, street furniture)	0.15	ha	€14,000	Prev. Job	€2,100
3	Water main diversion	30	m	€1,500	Prev. Job	€45,000
4	Sewer diversion	30	m	€1,000	Prev. Job	€30,000
5	Sewer pump station disruption	1	no.	€10,000	Prev. Job	€10,000
6	Culvert construction / rehabilitation (0.9m dia) - inc excavation, supports and backfilling	30	m	€510	Prev. Job	€15,300
7	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
8	Trash Screen	2	no.	€10,000	Prev. Job	€20,000
9	Manhole - inc excavation, supports and backfilling	2	no.	€2,000	SPONS 2022	€4,000
10	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000
					Total construction cost	€164,400

Element 4 Construction Costs

Castlefinn Area - Earth Embankment

Quantities generated from GIS modelling and assumed embankment cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	10,179	m³
Clay core Volume	4,445	m³
Cutoff Volume	210	m³
Footprint Area	4,525	m²
Surface Area	4,747	m²
Length	210	m
Max Height	5.23	m
Volume of old embankment (reused)	9404	m³

Clashes

Category	Type	Description	Quantity
Utility	Not known		
Environmental	Invasive species		
Infrastructure	None identified		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	1.23	acre	€15,000	Prev. Job	€18,442
2	Clearance - Vegetation killing	0.50	ha	€230	Prev. Job	€114
3	Clearance - Invasive species	0.50	ha	€5,000	Prev. Job	€2,489
4	Clearance - trees	50.0	no.	€90	Prev. Job	€4,500
5	Clearance - Site clearance & disposal	0.50	ha	€14,000	Prev. Job	€6,969
6	Excavation - Topsoil strip & stockpile	1493	m³	€8	Prev. Job	€11,946
7	Excavation - Cutting (inc old embankment)	210	m³	€5	Prev. Job	€1,056
8	Disposal - Cutting (inc old embankment)	210	m³	€26	Prev. Job	€5,384
9	Filling - Provision of topsoil	1424	m³	€30	Prev. Job	€42,723
10	Filling - Topsoil (300mm depth)	1424	m³	€9	Prev. Job	€12,105
11	Filling - Provision of clay fill	4445	m³	€35	Prev. Job	€155,575
12	Filling - Placing of clay fill	4445	m³	€15	Prev. Job	€66,675
13	Filling - Provision of outer fill	0	m³	€25	Prev. Job	€0
14	Filling - Placing of outer fill	5734	m³	€10	Prev. Job	€57,340
15	Geotextile mat	4747	m²	€4	Prev. Job	€18,988

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
16	Finishing - Grassing out	5222	m²	€1	Prev. Job	€5,483
17	Culvert through embankment (1.0 x 1.5m box) - inc excavation, supports and backfilling	62	m	€510	Prev. Job	€31,620
18	Headwall and outlet	4	no.	€10,000	Prev. Job	€40,000
19	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
20	Flap valve	1	no.	€10,000	Prev. Job	€10,000
21	Haul Road	540	m²	€90	Prev. Job	€48,600
22	Drainage	210	m	€35	Prev. Job	€7,350
				Total construction cost		€557,359

Element 5 Construction Costs

Castlefinn Area - Flood Storage (CPI)

Quantities generated from GIS modelling. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Excavation Area	4,733	m³
Excavation Volume	8,518	m³

Clashes

Category	Type	Description	Quantity
Utility	Not known		
Environmental	Invasive species		
Infrastructure	None identified		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

Description	Quantity	Unit	Rate	Source	Total
1. Land compensation	1.29	acre	€50,000	Prev. Job	€64,295
2. Clearance - Vegetation killing	0.52	ha	€230	Prev. Job	€120
3. Clearance - Invasive species	0.52	ha	€5,000	Prev. Job	€2,603
4. Clearance - Site clearance & disposal	0.52	ha	€14,000	Prev. Job	€7,289
5. Excavation - Topsoil strip & stockpile	2811	m³	€8	Prev. Job	€22,489
6. Excavation - Cutting (inc old embankment)	8518	m³	€5	Prev. Job	€42,848
7. Disposal - Cutting (inc old embankment)	8518	m³	€15	Prev. Job	€127,776
8. Finishing - Grassing out	5206	m²	€1	Prev. Job	€5,466
				Total construction cost	€272,885

Element 6 Construction Costs

Castlefinn Area - Upstream Storage

Quantities generated from ICM modelling and assumed embankment cross sectional makeup. Assumed 1 in 3 side slopes with 2m wide crest and clay core /cutoff. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	476	m³
Clay core Volume	286	m³
Cutoff Volume	50	m³
Footprint Area	666	m²
Land Compensation Area	85,482	m³
Surface Area	697	m²
Length	50	m²
Max Height	2.00	m
Volume of old embankment	0	m³

Clashes

Category	Type	Description	Quantity
Utility	Not known		
Environmental	Invasive species		
Infrastructure	None identified		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	23.23	acre	€10,000	Prev. Job	€232,254
2	Clearance - Vegetation killing	0.07	ha	€230	Prev. Job	€17
3	Clearance - Invasive species	0.07	ha	€5,000	Prev. Job	€366
4	Clearance - trees	0.0	no.	€90	Prev. Job	€0
5	Clearance - Site clearance & disposal	0.07	ha	€14,000	Prev. Job	€1,026
6	Excavation - Topsoil strip & stockpile	220	m³	€8	Prev. Job	€1,758
7	Excavation - Cutting (inc old embankment)	50	m³	€5	Prev. Job	€252
8	Disposal - Cutting (inc old embankment)	50	m³	€26	Prev. Job	€1,282
9	Filling - Provision of topsoil	209	m³	€30	Prev. Job	€6,273
10	Filling - Topsoil (300mm depth)	209	m³	€9	Prev. Job	€1,777
11	Filling - Provision of clay fill	286	m³	€35	Prev. Job	€10,010
12	Filling - Placing of clay fill	286	m³	€15	Prev. Job	€4,290
13	Filling - Provision of outer fill	190	m³	€25	Prev. Job	€4,750
14	Filling - Placing of outer fill	190	m³	€10	Prev. Job	€1,900
15	Geotextile mat	697	m²	€4	Prev. Job	€2,788

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
16	Finishing - Grassing out	767	m²	€1	Prev. Job	€805
17	Culvert through embankment (1.0 x 1.5m box) - inc excavation, supports and backfilling	12	m	€510	Prev. Job	€6,120
18	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
19	Trash Screen	0	no.	€10,000	Prev. Job	€0
20	Flap valve	0	no.	€10,000	Prev. Job	€0
21	Haul Road	615	m²	€90	Prev. Job	€55,350
					Total construction cost	€351,017

Element 7 Construction Costs

Property relocation

Quantities generated from GIS property counts. Rates generated from current market data for similar property types and from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Number of properties	33	no.
Size of house	350.0	m³

Clashes

Category	Type	Description	Quantity
Utility	general services		1.0
Infrastructure	None identified		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	New houses	1.0	no.	€141,918	Data for similar properties from sales register on www.daft.ie	€141,918
2	Outbuildings	1.0	no.	€81,894		€81,894
3	Relocation costs and administration	1.0	no.	30%	Data	€67,144
4	Demolition of buildings	800	m³	€17	Prev. Job	€13,840
5	Decommisioning of services	1	no.	€10,000	Prev. Job	€10,000
					Total construction cost	**€314,796**

Operation and Maintenance

The various elements of this option will have associated operation and maintenance (O&M) costs. Costs are dependant on the responsible body (eg local authority, government body, private party), the complexity of the element (eg moving parts, high precision tolerances), and the robustness of the element (eg rate of degradation, risk of collapse).

Bridge Burn Area - Culvert upgrade

Annual O&M cost	€	582
Assumptions	Cost based on a rate of €582/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Bridge Burn Area - Earth Embankment

Annual O&M cost	€	1,022
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Castlefinn Area - Culvert upgrade (Reduced)

Annual O&M cost	€	472
Assumptions	Cost based on a rate of €472/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Castlefinn Area - Earth Embankment

Annual O&M cost	€	572
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Castlefinn Area - Flood Storage (CPI)

Annual O&M cost	€	-
Assumptions	No cost	

Castlefinn Area - Upstream Storage

Annual O&M cost	€	472
Assumptions	Cost based on a rate of €472/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Total O&M Annual Costs

O&M costs per year	**€**	**3,120**

Whole Life Cost

Design Life

Bridge Burn Area - Culvert upgrade	50yrs
Bridge Burn Area - Earth Embankment	50yrs
Castlefinn Area - Culvert upgrade (Reduced)	50yrs
Castlefinn Area - Earth Embankment	50yrs
Castlefinn Area - Flood Storage (CPI)	50yrs
Castlefinn Area - Upstream Storage	50yrs
Property relocation	50yrs

Financial Assumptions

Financial period	50yrs
Discount rate	4%

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
0	1.000			-	-
1	0.962	3,140,739		3,019,941	-
2	0.925		3,120	-	2,885
3	0.889		3,120	-	2,774
4	0.855		3,120	-	2,667
5	0.822		3,120	-	2,565
6	0.790		3,120	-	2,466
7	0.760		3,120	-	2,371
8	0.731		3,120	-	2,280
9	0.703		3,120	-	2,192
10	0.676		3,120	-	2,108
11	0.650		3,120	-	2,027
12	0.625		3,120	-	1,949
13	0.601		3,120	-	1,874
14	0.577		3,120	-	1,802
15	0.555		3,120	-	1,732
16	0.534		3,120	-	1,666
17	0.513		3,120	-	1,602
18	0.494		3,120	-	1,540
19	0.475		3,120	-	1,481
20	0.456		3,120	-	1,424
21	0.439		3,120	-	1,369
22	0.422		3,120	-	1,317
23	0.406		3,120	-	1,266
24	0.390		3,120	-	1,217
25	0.375		3,120	-	1,170
26	0.361		3,120	-	1,125
27	0.347		3,120	-	1,082
28	0.333		3,120	-	1,040
29	0.321		3,120	-	1,000
30	0.308		3,120	-	962
31	0.296		3,120	-	925
32	0.285		3,120	-	889
33	0.274		3,120	-	855
34	0.264		3,120	-	822
35	0.253		3,120	-	791
36	0.244		3,120	-	760
37	0.234		3,120	-	731
38	0.225		3,120	-	703
39	0.217		3,120	-	676
40	0.208		3,120	-	650
41	0.200		3,120	-	625

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
42	0.193		3,120	-	601
43	0.185		3,120	-	578
44	0.178		3,120	-	556
45	0.171		3,120	-	534
46	0.165		3,120	-	514
47	0.158		3,120	-	494
48	0.152		3,120	-	475
49	0.146		3,120	-	457
50	0.141		3,120	-	439
				€ 3,019,941.35	**€ 64,026.98**

Optimism Bias

The starting (upper bound) Optimism Bias for strategy costs (pre-feasibility stage) is 60%. The Optimism Bias (OB) consists of risk components. Each risk component contributes a pre-defined percentage of overall OB factor. These risk components can be reduced for individual strategies or schemes if demonstrable action to minimise risks has been taken, or other evidence provided that risks are not applicable to the degree indicated. In which case the revised sum of risk components should be divided by 100 and multiplied by 60 to obtain the new OB factor.

Risk Component		Definition	%	Adjustment comment	Adj %
Procurement	Late contractor involvement in design	Late involvement of the contractor in the design leads to redesign or problems during construction	1	No adjustment	1
	Dispute and claims occurred	Disputes and claims occur where no mechanisms exist to manage effectively adversarial relationships between project stakeholders	11	**Contract will provide a suitable mechanism to address disputes and claims**	**5**
	Other	Other factors that relate to procurement which affect the final project cost	1	No adjustment	1
Project-specific	Design complexity	The complexity of design (including requirements, specifications and detailed design) requires significant management, impacting on final project costs	4	**Design is not considered overly complex and is accounted for as an individual item in the option summary**	**2**
	Degree of innovation	The degree of innovation required due to the nature of the project requires unproven methods to be used	4	**No unproven methods being used**	**1**
	Environmental impact	The project has a major impact on its adjacent area leading to objection from neighbours and the general public	13	**Retained at this level due to the potential for objection to the works in the upper catchment.**	**13**
	Other	Other project-specific factors which affect the final project cost	9	No adjustment	9
Client specific	Inadequacy of Business Case	The project scope changes as a result of the poor quality of requirement specifications and inadequate project scope definition	23	**An extensive project scope is being used with an established business case model. While risk remains it can be reduced.**	**12**
	Funding availability	Project delays or changes in scope occur as a result of the availability of funding (e.g. departmental budget spent or insufficient contingency funds)	2	No adjustment	2
	Project management team	The project management team's capabilities and/or experience impact on final project costs	1	No adjustment	1

Risk Component		Definition	%	Adjustment comment	Adj %
	Poor project intelligence	The quality of initial project intelligence (e.g. preliminary site investigation, user requirements surveys etc.) impacts on the occurrence of unforeseen problems and costs	8	No adjustment	8
Environment	Public relations	A high level of effort is required to address public concern about the project, which impacts on the final project cost	5	**Engagement has already occurred to inform public of project. They are broadly supportive.**	**3**
	Site characteristics	The characteristics of the proposed environment for the project are highly sensitive to the project's environmental impacts (e.g. Greenfield site with badger setts, or contaminated brownfield site)	4	No adjustment	4
External influences	Economic	The project costs are sensitive to economic influences such as higher-than-expected construction cost inflation, oil price shocks etc.	5	**It is likely that project costs will be affected by construction cost inflation and oil price increases.**	**20**
	Legislation/regulations	The project costs are sensitive to legislation and regulation changes, e.g. health and safety and building regulations	4	No adjustment	4
	Technology	The project costs are sensitive to technological advancements, e.g. the effects of obsolescence.	4	**It is not expected that the project will be sensitive to technological advancements, constructions methods are well established.**	**2**
	Other	Other external influencing factors which affect the final project cost	1	No adjustment	1
		TOTAL	100	TOTAL	89
Optimism Bias -		**Upper Bound**	**60**	**Adjusted**	**53.4**

Option 2 Summary

PV Construction Costs (year 1)				**€3,019,941**
Bridge Burn Area - Culvert upgrade	€717,099			
Bridge Burn Area - Earth Embankment	€778,023			
Castlefinn Area - Culvert upgrade (Reduced)	€158,077			
Castlefinn Area - Earth Embankment	€535,922			
Castlefinn Area - Flood Storage (CPI)	€272,885			
Castlefinn Area - Upstream Storage	€351,017			
Basic Construction Cost (BCC)	**€2,813,023**			
Property relocation	€302,688			
Preliminary Costs		15.15% of BCC	€ 426,238	
Ground Investigation		5% of BCC	€ 150,997	
Overall construction cost (OCC)				**€ 3,597,177**
Design & Envronmental Fees		8.6% of OCC	€ 309,357	
Site Supervision Fees		8% of OCC	€ 287,774	
	Total Fees		€ 597,131	
Archaeology & Environmental Mitigation		10% of OCC	€ 359,718	
Percent for Art		1% of OCC	€ 35,972	
PV Operation and Maintenance Costs (50yrs)			€ 64,027	
	Total		€ 459,716	
Sub-total				**€ 4,654,025**
Optimism Bias		53%	€ 2,485,249	
Total Cost				**€ 7,139,274**

Option 3 - CPI Defence Description - Castlefinn

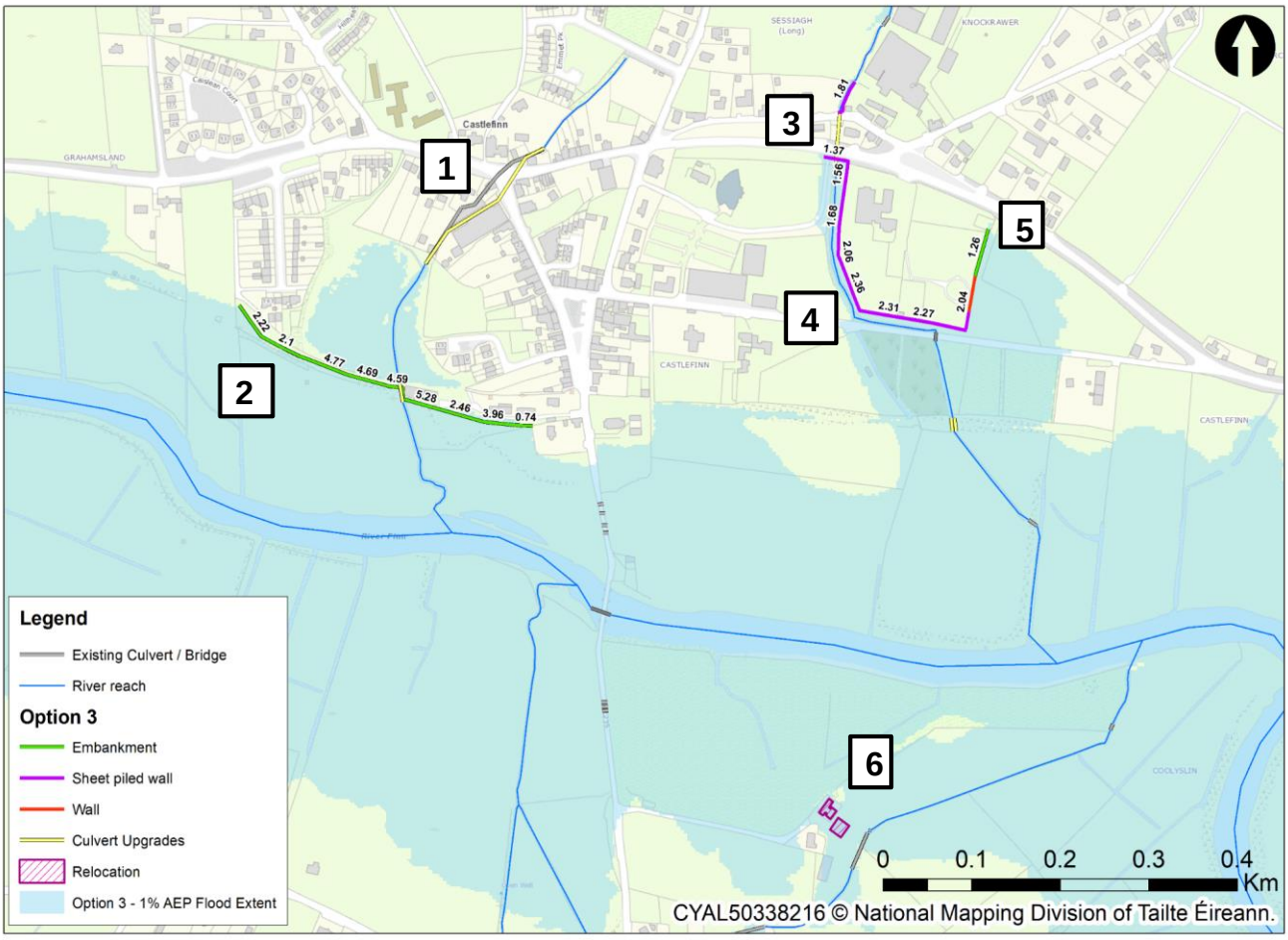
Shortlisted measures

The following measures have been shortlisted through the option screening process for the Castlefinn FRS. These measures can be combined to provide a flood scheme with the design SoP.
Measures have been grouped into three areas. The Bridge Burn Stream area, the Castlefinn WC area and the Corcullion Stream area.

List of elements

Bridge Burn	Castlefinn WC	Corcullion
1. Culvert Upgrade	3. Culvert Upgrade	6. Property Relocation
2. Earth Embankment	4. CPI Flood Wall	
	5. Earth Embankment	

Sketch of Option



Element 1 Construction Costs

Bridge Burn Area - Culvert upgrade

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	190	m
Culvert diameter	1.2	m
Manholes	4	no.

Clashes

Category	Type	Description	Quantity
Utility	Sewer	IW Combined	60.00
Utility	Electricity & telephone OH	EIR fibre optic	60.00
Utility	Watermain	Iw Watermain	60.00
Infrastructure	National road crossing		
Infrastructure	Buildings adjacent		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.00	no.	€15,000	Prev. Job	€15,000
2	Site clearance (fences, street furniture)	0.95	ha	€14,000	Prev. Job	€13,300
3	Cold Milling	190	m	€1.50	Prev. Job	€285
4	Water main diversion	60	m	€1,500	Prev. Job	€90,000
5	Sewer diversion	60	m	€1,000	Prev. Job	€60,000
6	Fibre Optic diversion	60	m	€3,000	Prev. Job	€180,000
7	Electric pole move	1	no.	€10,000	Prev. Job	€10,000
8	Demolish shed	1	no.	€10,000	Prev. Job	€10,000
9	Culvert t (1.2m dia) - inc excavation, supports and backfilling. Up to 3.5m deep, extensive constraints.	190	m	€1,020	Prev. Job	€193,800
10	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
11	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
12	Manhole - inc excavation, supports and backfilling	4	no.	€2,000	SPONS 2022	€8,000
13	45mm Hot Rolled Asphalt, HRA 35/14F Surface Course	570	m²	€45.74	SPONS 2022	€26,069.12
14	Binder Course Cold Milling	570	m²	€2.00	Prev. Job	€1,140
15	55mm Asphalt Concrete, AC20 DBM Binder Course	570	m²	€32.28	SPONS 2022	€18,401
16	100mm Asphalt Concrete, AC32 DBM Base	570	m²	€43.62	SPONS 2022	€24,861

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
17	350mm Type 3 Granular Sub Base	570	m²	€22.40	Prev. Job	€12,768
18	250mm Capping Layer	570	m²	€21.33	Prev. Job	€12,158
19	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000
20	Construct shed	1	no.	€30,000	Prev. Job	€30,000
					Total construction cost	€745,783

Element 2 Construction Costs

Bridge Burn Area - Earth Embankment

Quantities generated from GIS modelling and assumed embankment cross sectional makeup. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	14,483	m³
Clay core Volume	6,615	m³
Cutoff Volume	375	m³
Footprint Area	6,840	m²
Surface Area	7,170	m²
Length	375	m²
Max Height	6.19	m
Volume of old embankment (reused)	4101	m³

Clashes

Category	Type	Description	Quantity
Utility	Electricity OH cables		
Utility	WwTW		
Environmental	Invasive species		
Infrastructure	Electricity OH cables		
Land use	Defence footprint		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Land compensation	1.86	acre	€15,000	Prev. Job	€27,876
2	Clearance - Vegetation killing	0.75	ha	€230	Prev. Job	€173
3	Clearance - Invasive species	0.75	ha	€5,000	Prev. Job	€3,762
4	Clearance - trees	50	no.	€90	Prev. Job	€4,500
5	Clearance - Site clearance & disposal	0.75	ha	€14,000	Prev. Job	€10,534
6	Excavation - Topsoil strip & stockpile	2257	m³	€8	Prev. Job	€18,058
7	Excavation - Cutting (inc old embankment)	375	m³	€5	Prev. Job	€1,886
8	Disposal - Cutting (inc old embankment)	375	m³	€26	Prev. Job	€9,615
9	Filling - Provision of topsoil	2151	m³	€30	Prev. Job	€64,530
10	Filling - Topsoil (300mm depth)	2151	m³	€9	Prev. Job	€18,284
11	Filling - Provision of clay fill	6615	m³	€35	Prev. Job	€231,525
12	Filling - Placing of clay fill	6615	m³	€15	Prev. Job	€99,225
13	Filling - Provision of outer fill	3767	m³	€25	Prev. Job	€94,175
14	Filling - Placing of outer fill	7868	m³	€10	Prev. Job	€78,680
15	Geotextile mat	7170	m²	€4	Prev. Job	€28,680
16	Finishing - Grassing out	7887	m²	€1	Prev. Job	€8,281
17	Culvert through embankment (1.2m dia) - inc excavation, supports	31	m	€510	Prev. Job	€15,810

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
18	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
19	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
20	Flap valve	1	no.	€10,000	Prev. Job	€10,000
21	Haul Road	225	m²	€180	Prev. Job x 2	€40,500
22	Drainage	375	m	€35	Prev. Job	€13,125
					Total construction cost	€809,219

Element 3 Construction Costs

Castlefinn Area - Culvert upgrade

Quantities generated from GIS modelling and quantities listed. See Preliminary Buildability, Operation & Maintenance Report for details of assumed construction makeup. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Culvert length	55	m
Culvert diameter	1.3	m
Manholes	1	no.

Clashes

Category	Type	Description	Quantity
Utility	Sewer	IW Combined	30.00
Utility	Electricity & telephone OH	EIR fibre optic	30.00
Utility	Watermain	Iw Watermain	30.00
Utility	Pumping station		1.00
Infrastructure	National road crossing		1.00
Infrastructure	Minor road crossing		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Traffic Management	1.0	no.	€10,000	Prev. Job	€10,000
2	Site clearance (fences, street furniture)	0.28	ha	€14,000	Prev. Job	€3,850
3	Cold Milling	25	m	€1.50	Prev. Job	€38
4	Sewer diversion	30	m	€1,500	Prev. Job	€45,000
5	Water main diversion	30	m	€1,000	Prev. Job	€30,000
6	Fibre Optic diversion	30	m	€3,000	Prev. Job	€90,000
7	Sewer pump station disruption	1	no.	€10,000	Prev. Job	€10,000
8	Culvert (1.35m dia) - inc excavation, supports and backfilling, 2.5m deep.	55	m	€510	Prev. Job	€28,050
9	Headwall and outlet	2	no.	€10,000	Prev. Job	€20,000
10	Trash Screen	1	no.	€10,000	Prev. Job	€10,000
11	Manhole - inc excavation, supports and backfilling	1	no.	€2,000	SPONS 2022	€2,000
12	45mm Hot Rolled Asphalt, HRA 35/14F Surface Course	75	m²	€45.74	SPONS 2022	€3,430
13	Binder Course Cold Milling	75	m²	€2.00	Prev. Job	€150
14	55mm Asphalt Concrete, AC20 DBM Binder Course	75	m²	€32.28	SPONS 2022	€2,421

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
15	100mm Asphalt Concrete, AC32 DBM Base	75	m²	€43.62	SPONS 2022	€3,271
16	350mm Type 3 Granular Sub Base	75	m²	€22.40	Prev. Job	€1,680
17	250mm Capping Layer	75	m²	€21.33	Prev. Job	€1,600
18	Reinstate garden	1	no.	€10,000	Prev. Job	€10,000
					Total construction cost	**€271,490**

Element 4 Construction Costs

US of Castlefinn - Flood Wall (Sheet Piled Wall)

Quantities generated from GIS modelling and a reinforced concrete wall makeup on sheet pile foundation. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Working Area	4734.42	m²
Footprint	512.22	m²
Base Volume	434.22	m³
Stem Volume	431.17	m³
Stem Face	1077.93	m²
Exposed Stem Face	846.82	m²
Length	422.22	m²
Sheet pile tonnage	506.06	t
Average Height	2.03	m

Clashes

Category	Type	Area	Length	Description	Quantity
Environmental	Invasive species	14,200	-		-
Infrastructure	Farm building	-	-		1
Land use	Farm yard reinstatement	185	-		-
Land use	CPI garden reinstatement	-	283.66		-
Land use	Car park reinstatement	126.59	-		-
Land access	Not known	-	-		-
Ground contamination	Not known	-	-		-
Soil conditions	Not known	-	-		-

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Clearance - Invasive species	1.420	ha	€5,000	Prev. Job	€7,100
2	Clearance - trees	50	no.	€90	Prev. Job	€4,500
3	Clearance - Site clearance, vegetation killing, & disposal	0.96	ha	€2,800	Prev. Job	€2,793
4	Construction around farm building	1	no.	€50,000	Prev. Job	€50,000
5	Excavation - Topsoil strip & stockpile	4,734	m³	€11	Prev. Job	€49,711
6	Excavation - Cutting	512	m³	€11	Prev. Job	€5,378
7	Disposal - Cutting	512	m³	€15	Prev. Job	€7,427
8	Steel sheet pile	506	t	€1,500	Prev. Job	€759,090
9	Base Slab - Concrete	434	m³	€150	Prev. Job	€65,133
10	Base Slab - Reinforcement	34	t	€1,650	Prev. Job	€56,601
11	Base Slab - Trench fill	51	m³	€30	Prev. Job	€1,537
12	Base Slab - Formwork	169	m³	€81	Prev. Job	€13,680
13	Wall - Concrete	431	m³	€156	Prev. Job	€67,263
14	Wall - Reinforcement	34	t	€1,650	Prev. Job	€56,203
15	Wall - Formwork	2,156	m²	€81	Prev. Job	€174,625
16	Wall - Finish (Granite)	1,694	m²	€80	Prev. Job	€135,491

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
17	Coping stone	422	m	€75	Prev. Job	€31,667
18	Drainage	422	m	€70	Prev. Job	€29,555
19	Finishing - Grassing out	478	m²	€7	Prev. Job	€3,501
20	Carpark Reinstatement	127	m²	€78.43	Prev. Job	€9,928
21	Farmyard Reinstatement	56	m³	€187.92	Prev. Job	€10,430
22	Garden Reinstatement	341	m	€140	Prev. Job	€47,740
					Total construction cost	**€1,589,352**

Element 5 Construction Costs

US of Castlefinn - Earth Embankment

Quantities generated from ICM modelling and assumed embankment cross sectional makeup. Assumed 1 in 3 side slopes with 2m wide crest and clay core /cutoff. Rates generated from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Embankment Volume	453	m³
Clay core Volume	278	m³
Cutoff Volume	54	m³
Footprint Area	515	m²
Surface Area	537	m²
Length	54	m
Max Height	1.51	m
Volume of old embankment	0	m³

Clashes

Category	Type	Area	Length	Description	Quantity
Utility	Gravity sewer	-	50.00		-
Environmental	Invasive species	0.057	-		-
Infrastructure	Farm building and yard	246.85	-		1
Land use	Defence footprint	566.5	-		-
Land access	Not known	-	-		-
Ground contamination	Not known	-	-		-
Soil conditions	Not known	-	-		-

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	Clearance - trees	15	no.	€90	Prev. Job	€1,350
2	Clearance - Site clearance & disposal	0.057	ha	€14,000	Prev. Job	€793
3	Excavation - Topsoil strip & stockpile	170	m³	€11	Prev. Job	€1,784
4	Excavation - Cutting	54	m³	€11	Prev. Job	€567
5	Disposal - Cutting	54	m³	€15	Prev. Job	€783
6	Filling - Provision of topsoil	161	m³	€25	Prev. Job	€4,094
7	Filling - Provision of clay fill	278	m³	€35	Prev. Job	€9,730
8	Filling - Placing of clay fill	278	m³	€2	Prev. Job	€687
9	Filling - Provision of outer fill	175	m³	€28	Prev. Job	€4,862
10	Filling - Placing of outer fill	175	m³	€2	Prev. Job	€432
11	Geotextile mat	537	m²	€7	Prev. Job	€3,630
12	Finishing - Grassing out	591	m²	€7	Prev. Job	€4,330
13	Drainage	54	m	€35	Prev. Job	€1,890
				Total construction cost		**€34,931**

Element 6 Construction Costs

Property relocation

Quantities generated from GIS property counts. Rates generated from current market data for similar property types and from previous jobs, SPONS and the SEPA UCD as indicated below.

Quantities

Number of properties	1	no.
Size of house	350	m³

Clashes

Category	Type	Description	Quantity
Utility	general services		1.00
Infrastructure	None identified		
Environmental	Not known		
Land use	Not known		
Land access	Not known		
Ground contamination	Not known		
Soil conditions	Not known		

Cost Breakdown

	Description	Quantity	Unit	Rate	Source	Total
1	New houses	1.0	no.	€ 141,918	Data for similar properties from sales register on www.daft.ie	€141,918
2	Outbuildings	1.0	no.	€81,894		€81,894
3	Relocation costs and administration	1.0	no.	30%	Data	€67,144
4	Demolition of buildings	800	m³	€17	Prev. Job	€13,840
5	Decommisioning of services	1	no.	€10,000	Prev. Job	€10,000
					Total construction cost	**€314,796**

Operation and Maintenance

The various elements of this option will have associated operation and maintenance (O&M) costs. Costs are dependant on the responsible body (eg local authority, government body, private party), the complexity of the element (eg moving parts, high precision tolerances), and the robustness of the element (eg rate of degradation, risk of collapse).

Bridge Burn Area - Culvert upgrade

Annual O&M cost	€	582
Assumptions	Cost based on a rate of €582/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

Bridge Burn Area - Earth Embankment

Annual O&M cost	€	1,022
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Castlefinn Area - Culvert upgrade

Annual O&M cost	€	472
Assumptions	Cost based on a rate of €472/culvert/year. Maintenance includes for inspections, vegetation and trash clearance, minor repair work	

US of Castlefinn - Flood Wall (Sheet Piled Wall)

Annual O&M cost	€	211
Assumptions	Cost based on a rate of €0.5/m/year. Maintenance includes for vegetation control, inspections.	

US of Castlefinn - Earth Embankment

Annual O&M cost	€	147
Assumptions	Cost based on a rate of €2,725/km/year. Maintenance includes for vegetation control, inspections, vermin control, back drainage improvements.	

Total O&M Annual Costs

O&M costs per year	**€**	**2,434**

Whole Life Cost

Design Life

Bridge Burn Area - Culvert upgrade	50yrs
Bridge Burn Area - Earth Embankment	50yrs
Castlefinn Area - Culvert upgrade	50yrs
US of Castlefinn - Flood Wall (Sheet Piled Wall)	50yrs
US of Castlefinn - Earth Embankment	50yrs
Property relocation	50yrs

Financial Assumptions

Financial period	50yrs
Discount rate	4%

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
0	1.000			-	-
1	0.962	3,765,570		3,620,741	-
2	0.925		2,434	-	2,250
3	0.889		2,434	-	2,164
4	0.855		2,434	-	2,081
5	0.822		2,434	-	2,001
6	0.790		2,434	-	1,924
7	0.760		2,434	-	1,850
8	0.731		2,434	-	1,779
9	0.703		2,434	-	1,710
10	0.676		2,434	-	1,644
11	0.650		2,434	-	1,581
12	0.625		2,434	-	1,520
13	0.601		2,434	-	1,462
14	0.577		2,434	-	1,406
15	0.555		2,434	-	1,352
16	0.534		2,434	-	1,300
17	0.513		2,434	-	1,250
18	0.494		2,434	-	1,202
19	0.475		2,434	-	1,155
20	0.456		2,434	-	1,111
21	0.439		2,434	-	1,068
22	0.422		2,434	-	1,027
23	0.406		2,434	-	988
24	0.390		2,434	-	950
25	0.375		2,434	-	913
26	0.361		2,434	-	878
27	0.347		2,434	-	844
28	0.333		2,434	-	812
29	0.321		2,434	-	781
30	0.308		2,434	-	750
31	0.296		2,434	-	722
32	0.285		2,434	-	694
33	0.274		2,434	-	667
34	0.264		2,434	-	642
35	0.253		2,434	-	617
36	0.244		2,434	-	593
37	0.234		2,434	-	570
38	0.225		2,434	-	548
39	0.217		2,434	-	527
40	0.208		2,434	-	507
41	0.200		2,434	-	488
42	0.193		2,434	-	469
43	0.185		2,434	-	451
44	0.178		2,434	-	433
45	0.171		2,434	-	417
46	0.165		2,434	-	401

Year	Discount factor	Construction	O&M	PV Construction	PV O&M
47	0.158		2,434	-	385
48	0.152		2,434	-	370
49	0.146		2,434	-	356
50	0.141		2,434	-	343
				€ 3,620,741	**€ 49,950**

Optimism Bias

The starting (upper bound) Optimism Bias for strategy costs (pre-feasibility stage) is 60%. The Optimism Bias (OB) consists of risk components. Each risk component contributes a pre-defined percentage of overall OB factor. These risk components can be reduced for individual strategies or schemes if demonstrable action to minimise risks has been taken, or other evidence provided that risks are not applicable to the degree indicated. In which case the revised sum of risk components should be divided by 100 and multiplied by 60 to obtain the new OB factor.

Risk Component		Definition	%	Adjustment comment	Adj %
Procurement	Late contractor involvement in design	Late involvement of the contractor in the design leads to redesign or problems during construction	1	No adjustment	1
	Dispute and claims occurred	Disputes and claims occur where no mechanisms exist to manage effectively adversarial relationships between project stakeholders	11	**Contract will provide a suitable mechanism to address disputes and claims**	**5**
	Other	Other factors that relate to procurement which affect the final project cost	1	No adjustment	1
Project-specific	Design complexity	The complexity of design (including requirements, specifications and detailed design) requires significant management, impacting on final project costs	4	**Design is not considered overly complex and is accounted for as an individual item in the option summary**	**2**
	Degree of innovation	The degree of innovation required due to the nature of the project requires unproven methods to be used	4	**No unproven methods being used**	**1**
	Environmental impact	The project has a major impact on its adjacent area leading to objection from neighbours and the general public	13	**Environmental contraints have been considered at optioneering stage. No major constraints identified**	**6**
	Other	Other project-specific factors which affect the final project cost	9	No adjustment	9
Client specific	Inadequacy of Business Case	The project scope changes as a result of the poor quality of requirement specifications and inadequate project scope definition	23	**An extensive project scope is being used with an established business case model. While risk remains it can be reduced.**	**12**
	Funding availability	Project delays or changes in scope occur as a result of the availability of funding (e.g. departmental budget spent or insufficient contingency funds)	2	No adjustment	2
	Project management team	The project management team's capabilities and/or experience impact on final project costs	1	No adjustment	1

	Poor project intelligence	The quality of initial project intelligence (e.g. preliminary site investigation, user requirements surveys etc.) impacts on the occurrence of unforeseen problems and costs	8	No adjustment	8
Environment	Public relations	A high level of effort is required to address public concern about the project, which impacts on the final project cost	5	**Engagement has already occurred to inform public of project. They are broadly supportive.**	**3**
	Site characteristics	The characteristics of the proposed environment for the project are highly sensitive to the project's environmental impacts (e.g. Greenfield site with badger setts, or contaminated brownfield site)	4	No adjustment	4
External influences	Economic	The project costs are sensitive to economic influences such as higher-than-expected construction cost inflation, oil price shocks etc.	5	**It is likely that project costs will be affected by construction cost inflation and oil price increases.**	**20**
	Legislation/regulations	The project costs are sensitive to legislation and regulation changes, e.g. health and safety and building regulations	4	No adjustment	4
	Technology	The project costs are sensitive to technological advancements, e.g. the effects of obsolescence.	4	**It is not expected that the project will be sensitive to technological advancements, constructions methods are well established.**	**2**
	Other	Other external influencing factors which affect the final project cost	1	No adjustment	1
		TOTAL	100	TOTAL	82
Optimism Bias -		**Upper Bound**	**60**	**Adjusted**	**49.2**

Option 3 Summary

PV Construction Costs (year 1)				**€3,620,741**
Bridge Burn Area - Culvert upgrade	€717,099			
Bridge Burn Area - Earth Embankment	€778,095			
Castlefinn Area - Culvert upgrade	€261,048			
US of Castlefinn - Flood Wall (Sheet Piled Wall)	€1,528,223			
US of Castlefinn - Earth Embankment	€33,588			
Basic Construction Cost (BCC)	**€3,318,053**			
Property relocation	€302,688			
Preliminary Costs		13.81% of BCC	€ 458,098	
Ground Investigation		5% of BCC	€ 181,037	
Overall construction cost (OCC)				**€ 4,259,875**
Design & Envronmental Fees		8.6% of OCC	€ 366,349	
Site Supervision Fees		8% of OCC	€ 340,790	
	Total Fees		€ 707,139	
Archaeology & Environmental Mitigation		10% of OCC	€ 425,988	
Percent for Art		1% of OCC	€ 42,599	
PV Operation and Maintenance Costs (50yrs)			€ 49,950	
	Total		€ 518,536	
Sub-total				**€ 5,485,551**
Optimism Bias		49%	€ 2,698,891	
Total Cost				**€ 8,184,442**

Appendix F

Carbon costing sheets

F1. CASTLEFINN FLOOD PROTECTION SCHEME – OPTIONS APPRAISAL (CARBON COSTING REVIEW)

The following information details carbon costings for three different construction options for a flood defence scheme in Castlefinn, Donegal, Republic of Ireland. The scope covers embodied carbon from the materials involved in the construction of each scheme; carbon dioxide (CO_2) and carbon dioxide equivalent (CO_2e) gases generated through the construction process; any CO_2e from the operation and maintenance of the scheme; and finally, an estimated financial valuation of carbon based on price signals in regulated and voluntary carbon markets (summarised in Table F.1 and Figure F.1).

F1.1 Option descriptions

Option 1: Two earth embankments are to be constructed to the south of the town located along the old railway line with culverts through each embankment. These are to protect against flooding directly from the River Finn. The culvert of the Bridge Burn which flows under the N15 / R235 junction outside McGlynns will be re-built with a higher flow capacity. The culvert of the Castlefinn watercourse which flows from north to south under the N15 before emerging adjacent to the Castlefinn Partnership Initiative (CPI) Centre will be re-built with a higher flow capacity. A third earth embankment and wall will be constructed around the CPI in Castlefinn to protect against flooding from the Castlefinn watercourse. Included in Option 1 is the relocation of one residential property and outbuilding to the south of the River Finn.

Option 2: Retains the earth embankments as per Option 1 to the south of the town along the old railway lines to protect from direct flooding from the River Finn. The culverts of the Bridge Burn and on the Castlefinn watercourse are also retained in this option. The earth embankment and wall around the CPI is not included, but a storage solution upstream on the Castlefinn watercourse which includes an earth embankment. Included in Option 2 is the relocation of one settlement and outbuilding to the south of the River Finn, same as Option 1.

Option 3: The earth embankment along the railway line to the south-west of the town is retained from options 1 and 2, as are the culverts on the Bridge Burn and the Castlefinn watercourse. An additional culvert upgrade on the Castlefinn watercourse to the south of the CPI is included. The significant difference in option 3 is the replacement of the earth embankment in option 1 with a sheet piled wall to protect the CPI from direct flooding from the Castlefinn watercourse. Included in Option 3 is the relocation of one settlement and outbuilding to the south of the River Finn, same as Option 1 and 2.

F1.2 Option comparison

Table F.1 Overview of Option Comparison for each Life Cycle Assessment (LCA) Stage, A1-A5, with respective tonnes of carbon dioxide equivalent (tCO_2e) amounts. A1-A3 – Material extraction, transport to manufacturer and manufacturing; A4 – Material transport to site; and A5 - Construction process.

Activity	Option 1	Option 2	Option 3
Embodied carbon A1-3 (tCO_2e)	1744	1396	2686
Material transport A4 (tCO_2e)	297	262	227
Construction fuel usage A5 (tCO_2e)	475	475	560
Property relocation[1]	200	200	200
Total (tCO_2e)	**2716**	**2333**	**3681**
Estimated carbon value of option (€) [2]	**867,789**	**745,344**	**€1,175,816**

1. In addition to flood defence construction, all options include the relocation of a house and outbuilding to a nearby location. Reconstruction of a house involves a substantial embodied carbon and construction activity investment.

2. The estimated price of carbon is based on the BEIS central carbon value for the year 2028 (£272). This value has been converted to € using a conversion rate of £1 = €1.1745. The same conversion rate has been held constant throughout this report.

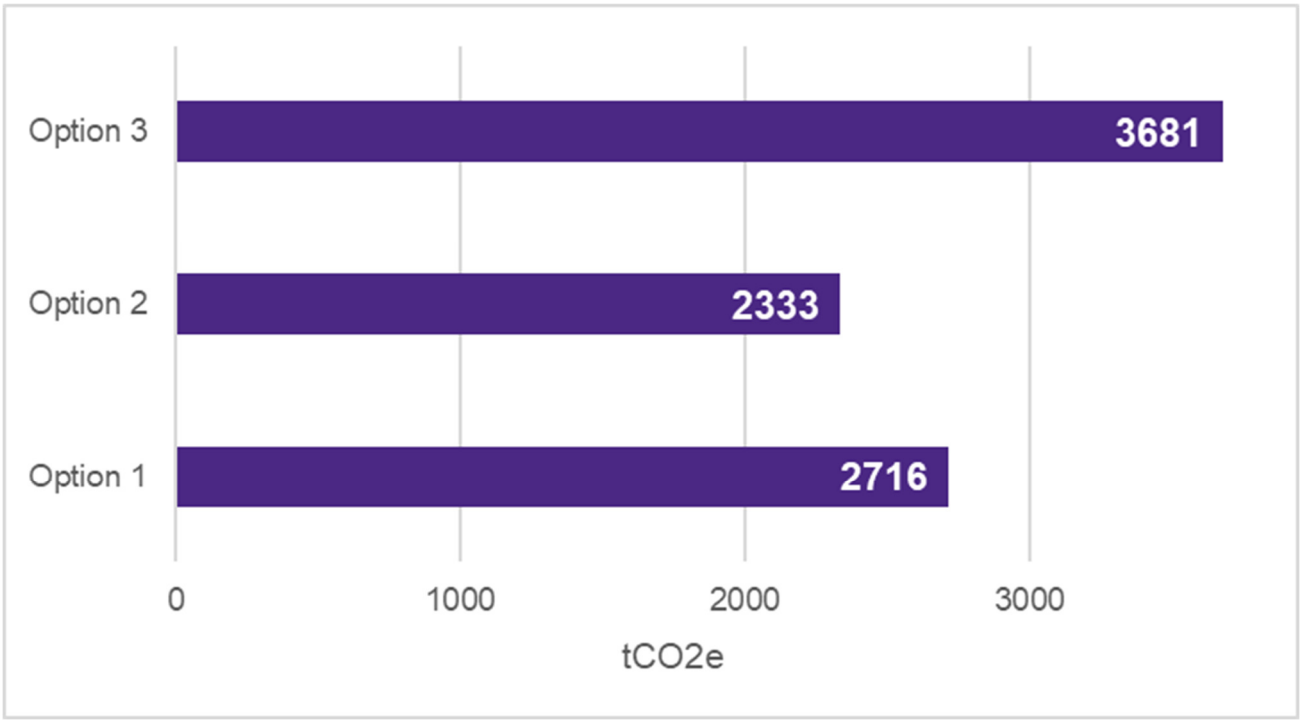


Figure F.1 Total tonnes of carbon dioxide equivalent (tCO_2e) greenhouse gases for each of the three Options in Castlefinn.

F1.3 Methodology

Through consideration of the Life Cycle Assessment (LCA) Stages A1-A5, the data sources and methodology applied attempts to capture all emissions generated and associated with scope 1, 2 and 3 emissions. Scope 1 emissions refer to those emissions produced directly as a result of works, such as the burning of fuel in machinery while on site. Scope 2 emissions are those that are indirectly generated as a result of the scheme such as the emissions associated with energy provided by a supplier, e.g., electricity from the mains. Scope 3 emissions then include all emission sources not covered by scope 1 and 2, such as the emissions produced as a result of making the elements for the scheme, e.g., concrete culverts, steel manholes, fencing.

Emissions are presented in carbon dioxide equivalent (CO_2e) terms. CO_2e is a term for describing different greenhouse gases (GHG) in a common unit. For any quantity and type of GHG, CO_2e relates the amount of CO_2 which would have the equivalent global warming impact for that type of GHG.

Stages A1 – A3 (material extraction, transport to manufacturer and manufacturing)

Embodied carbon of construction materials for the A1-A3 Life Cycle Assessment (LCA) stages has been established by using carbon factors and material densities provided from the following sources:

- OneClick LCA – life-cycle assessment software containing a large database of building material/product characteristics and embodied carbon intensities, based on published environmental product declarations (EPDs) and carbon intensities for generic construction materials.
- Institution of Civil Engineers (ICE) Database V3.0 – a database of selected carbon intensities for general bulk construction materials such as concrete or aggregates.
- National Highways Carbon tool – an infrastructure calculation tool also containing carbon intensity data together with typical product types and dimensions applicable to highways and civil engineering.

These data sources were used to calculate the embodied carbon emissions from building material types and quantities for each flood defence scheme option as specified in the estimated Bill of Materials provided by the design team.

Stage A4 – Material transport to site

Material transport to site has been calculated by calculating the mass of all materials required for each option, based on the bill of materials. Materials are then conservatively assumed to be transported in four axle rigid heavy goods vehicles (HGVs), with an estimated 20 tonne pay load. This may vary in practice with larger articulated HGVs or smaller delivery vans, and materials where the payload is volume- rather than mass-limited but is a reasonably representative assumption. Ten trips were also added to each option to account for materials provided in lengths, as mass was unable to be derived from this.

The relevant emissions factor (rigid HGV >17 tonnes) was selected using the Department for Business, Energy, and Industrial Strategy (BEIS) greenhouse gas (GHG) reporting conversion factors (2022) for both an unladen and fully laden lorry, to represent a return journey for material deliveries. Well-to-tank (WTT), which

accounts for the upstream scope 3 emissions associated with extraction, refining and transportation of the raw fuel sources to an organisation's site (or asset), prior to their combustion, were also included.

Calculations of material transport to site assumes a delivery radius 140km, the distance from Castlefinn to Belfast Docks. It is likely that many of the bulk materials will be sourced nearer to the site, however this conservative assumption ensures reasonably conservative coverage of any CO_2e emissions associated with material transport to site for the schemes.

Stage A5 – Construction process

Emissions from the construction stage of the schemes have been based on estimated fuel use for construction plant. Construction stage fuel consumption for each option was established through discussion with the design team, who based assumptions on construction site fuel consumption from a current project. The example project is a flood scheme constructing reinforced concrete walls and flood embankments, and it has been established that they are using on average, 2,500L of diesel per week, enabling 100m of defence wall to be erected per month. For Castlefinn, there are large earth embankments roughly 3 times the average of those assumed in the example project. This increase in earth embankments is estimated to result in an average fuel usage of 2,500L per week to enable 30m of defence wall to be erected each month. The design team then used this information to scale in line with the size of this project, based on length of flood defence structures for each option, to establish an estimated construction period and therein, estimated construction fuel consumption for the construction phase. The BEIS (2022) GHG reporting conversion factor for 'gas oil' (red diesel) in litres/kgCO_2e was used to calculate resulting GHG emissions.

Stage B – Maintenance and Operation

All three of the options are passive designs which will not require any material amount of operational energy to function. While maintenance work required during the design lifetime of the schemes may also involve materials and energy consumption with resulting GHG emissions, the time period in which any major maintenance work would be expected is likely to be when very substantial decarbonisation of the construction sector has occurred, in line with Ireland's obligation to achieve net zero emissions no later than 2050, with a reduction of 51% by 2030, as committed to as part of the Climate Action and Low Carbon Development Act (2021), and detailed within the Climate Action Plan (2021).

F1.4 Carbon Pricing

There are a number of approaches to placing a monetary value on tonnes of CO_2e, with several price signals available and a very wide range of possible values. These include the market price of voluntary carbon offsets, the price of mandatory carbon credits traded under the UK or EU Emissions Trading Schemes (ETS), or non-market prices such as the social cost of carbon (a damage cost) or a marginal abatement cost consistent with some specified emissions reduction target and assumed social/technology pathways. A selected summary of potential values is set out below in Table F.2.

Table F.2 Potential carbon prices

Source	Value (€/tCO_2e)	Notes
Compliance markets		
UK ETS	€76 to €94	Averages in 2021 and 2022; high variability and a cost containment mechanism triggered in some months.
EU ETS	€83	Average in 2022; high variability.
Voluntary markets and policy		
Verified offset credits	€9 to €45	Range of offset projects verified through Gold Standard and Ecologi; and incorporating Fairtrade recommended minimum price for forest management carbon offset.
London Plan offset fund	€112	2021 price recommended by GLA; boroughs can set higher or lower prices.
UK Treasury Green Book carbon values	€291 to €444 (2028: €320)	£248 to £378 BEIS central values, 2022-2050.
Irish Carbon Tax	€41	As of May 1, 2022. Only applies to carbon emitted through the direct use of fossil fuels like oil, petrol, diesel and gas in heating homes and businesses or running cars and trucks.

Regarding carbon pricing the Republic of Ireland participates in the EU ETS, as well as having an additional carbon tax that applies a tax of €41 per tonne (as of May 1, 2022) of carbon emitted through the direct use of fossil fuels like oil, petrol, diesel and gas in heating homes and businesses or running cars and trucks. While information on carbon pricing from the Republic of Ireland has been considered, the carbon price selected for this assessment are those published by BEIS in the Green Book. The Green Book provides guidance on how to appraise and account for carbon emissions when considering different policies, programmes, and projects. Unlike the Irish carbon tax and many carbon taxation systems, the values established are not arbitrarily established based on varying factors such as what value of carbon a market or consumers can realistically cope with. The BEIS Green Book policy appraisal is the most appropriate option available as the factors used are marginal abatement costs, i.e., representing the cost of the next least-expensive action to provide an equivalent reduction in CO_2 each year on a social/technology pathway consistent with meeting the UK's 2050 net zero goal, in 2020 prices[1]. Post-2050, the 2050 value is increased by 1.5% annually in line with BEIS guidance. It is recognised that these values are higher than other current market prices for carbon: however, this represents a market failure, and the 'true' value (as modelled by BEIS) should be applied when looking to conservatively establish the financial cost of carbon. The BEIS central carbon value for 2028 is €320 (£272), which has been selected as a conservative measure as it is expected that construction works on the scheme will not start before 2025, at the earliest, so this value is a conservative assumption of the cost of carbon for this scheme.

[1] No adjustment is made to inflate this to 2022 prices, as the BEIS GDP deflator values indicate that 2022 prices should be 99.7% of 2020 due to the recessionary effects of Covid-19, and a 0.3% adjustment is not meaningful to apply within the other uncertainties of the assessment. And likewise, no deflator adjustment from future year prices to 2020 or 2022 real prices is required, as the BEIS carbon values are already expressed in 2020 real prices.

F1.5 Conclusion

The difference in the GHG emissions estimated for Option 1 and 2 is due to the presence of the flood wall and additional earth embankment in Option 1. Option 3 requires the construction of a significant flood wall that is sheet piled, thus resulting in the total emissions being significantly higher compared to Options 1 and 2.

Further GHG emission reduction opportunities (beyond selecting the design option with the least material requirements) lie in consideration of materials used, such as making use of concrete with a percentage of Ground Granulated Blast-furnace Slag (GGBS) used as cementitious binder to reduce the amount of carbon intensive cement in the product.

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F1.6 Embodied Carbon details

Materials - Option 1				Materials - Option 2				Materials - Option 3			
Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e
Element 1 - culvert upgrade				**Element 1 - culvert upgrade**				**Element 1 - culvert upgrade**			
Culvert t (1.2m diameter) – inc. excavation, supports and backfilling	m	190.00	17.10	Culvert t (1.2m diameter) – inc. excavation, supports and backfilling	m	190.00	17.10	Culvert t (1.2m diameter) – inc. excavation, supports and backfilling	m	190.00	17.10
Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94
Trash Screen	no	10	0.1	Trash Screen	no	10	0.1	Trash Screen	no	10	0.1
Asphalt	m^2	570.00	9.58	Asphalt	m^2	570.00	9.58	Asphalt	m^2	570.00	9.58
350mm Type 3 Granular Sub Base	m^2	570.00	0.00	350mm Type 3 Granular Sub Base	m^2	570.00	0.00	350mm Type 3 Granular Sub Base	m^2	570.00	0.00
250mm Capping Layer	m^2	570.00	0.00	250mm Capping Layer	m^2	570.00	0.00	250mm Capping Layer	m^2	570.00	0.00
250mm Capping Layer	m^2	570.00	0.00	250mm Capping Layer	m^2	570.00	0.00	250mm Capping Layer	m^2	570.00	0.00
Element 2 - Earth Embankment				**Element 2 - Earth Embankment**				**Element 2 - Earth Embankment**			
topsoil (300 mm deep)	m^3	2151.00	0.07	topsoil (300 mm deep)	m^3	2151.00	0.07	topsoil (300 mm deep)	m^3	2151.00	0.07
Clay	m^3	6615.00	766.02	Clay	m^3	6615.00	766.02	Clay	m^3	6615.00	766.02
Outer fill	m^3	3767.00	1.47	Outer fill	m^3	3767.00	1.47	Outer fill	m^3	3767.00	1.47
geotextile matt	m^2	7170.00	17.23	geotextile matt	m^2	7170.00	17.23	geotextile matt	m^2	7170.00	17.23
haul road (0.5 m depth)	m^2	225.00	0.45	haul road (0.5 m depth)	m^2	225.00	0.45	haul road (0.5 m depth)	m^2	225.00	0.45
drainage	m	375.00	2.52	drainage	m	375.00	0.00	drainage	m	375.00	2.52

Materials - Option 1				Materials - Option 2				Materials - Option 3			
Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e
culvert 1200 mm diameter	m	31.00	2.79	culvert 1200 mm diameter	m	31.00	2.79	culvert 1200 mm diameter	m	31.00	2.79
Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94
Trash Screen	no	10	0.1	Trash Screen	no	10	0.1	Trash Screen	no	10	0.1
Element 3 - Culvert upgrade				**Element 3 - Culvert Upgrade**				**Element 3 - Culvert upgrade**			
Culvert t (1.35 m diameter) – inc. excavation, supports and backfilling	m	55.00	5.78	Culvert t (0.9m diameter) – inc. excavation, supports and backfilling	m	30.00	1.80	Culvert t (1.35 m diameter) – inc. excavation, supports and backfilling	m	55.00	5.78
Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94	Headwall and outlet	no	2.00	0.94
Trash Screen	no	10	0.1	Trash screen	no	20	0.2	Trash Screen	no	10	0.1
Asphalt	m^2	75.00	1.26	**Element 4 - Earth Embankment**				Asphalt	m^2	75.00	1.26
350 mm Type 3 Granular Sub Base	m^2	75.00	0.00	topsoil (300 mm deep)	m^3	1424.00	0.05	350 mm Type 3 Granular Sub Base	m^2	75.00	0.00
250 mm Capping Layer	m^2	18.75	0.00	Clay	m^3	4445.00	514.73	250 mm Capping Layer	m^2	18.75	0.00
Element 4 - Earth Embankment				Outer fill	m^3	0.00	0.00	**Element 4 - Flood Wall**			
topsoil (300 mm deep)	m^3	1424.00	0.05	geotextile matt	m^2	4747.00	11.41	Steel sheet pile	t	506.06	1396.73
Clay	m^3	4445.00	514.73	haul road (0.5 m depth)	m^2	540.00	1.08	Base Slab - Concrete	m^3	434.22	135.48
Outer fill	m^3	0.00	0.00	drainage	m	210.00	0.00	Base Slab - Reinforcement	t	34.30	68.26
geotextile matt	m^2	4747.00	11.41	culvert 1.0 x 1.5 m box –	m3	76.26		Base Slab - Trench fill	m^3	51.22	11.16

Materials - Option 1				Materials - Option 2				Materials - Option 3			
Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e
				inc. excavation, supports and backfilling - 62 m long							
haul road (0.5 m depth)	m²	540.00	1.08	Headwall and outlet	no	4.00	1.87	Base Slab - Formwork	m²	168.89	0.01
drainage	m	210.00	1.41	Trash Screen	no	10	0.1	Wall - Concrete	m³	431.17	134.53
culvert 1.0 x 1.5 m box - inc excavation, supports and backfilling - 62 m long	m³	76.26	31.11					Wall - Reinforcement	t	34.06	67.78
Headwall and outlet	no	4.00	1.87	**Element 5 - Storage (CPI)**							
Trash Screen	no	10	0.1	No elements with embodied carbon being added				Wall - Formwork	m²	2155.86	0.07
								Wall - Finish (Granite)	m²	1693.64	0.22
Element 5 - CPI Bund				**Element 6 - Storage (US)**							
				topsoil (300 mm deep)	m³	209.00	0.01	Coping stone (600x200mm assumed)	m	422.22	6.58
topsoil (300 mm deep)	m³	962.00	0.03	Clay	m³	286.00	33.12	Drainage	m	422.22	2.84
Clay	m³	1860.00	215.39	Outer fill	m³	190.00	0.07	**Element 5 - Earth Embankment**			
Outer fill	m³	850.00	0.33	geotextile matt	m²	697.00	1.67	topsoil (300 mm deep)	m³	161.00	0.01
geotextile matt	m²	3205.00	7.70	haul road (0.5 m depth)	m²	615.00	1.23	Clay	m³	278.00	32.19

Materials - Option 1				Materials - Option 2				Materials - Option 3			
Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e
Drainage	m	400.00	2.69	culvert 1.0 x 1.5 m box – inc. excavation, supports and backfilling - 12m long	m^3	14.76	6.02	Outer fill	m^3	175.00	0.07
Element 6 - US of N15 Wall				Headwall and outlet	no	2.00	0.94	geotextile matt	m^2	537.00	1.29
Base Slab - Concrete	m^3	47.00	14.66	Trash Screen	no	0.00	0.00	drainage	m	210.00	1.41
Base Slab - Reinforcement	t	4.00	93.53	**Element 7 - Property Relocate**				**Element 6 - Property Relocate**			
Base Slab - Trench fill	m^3	12.00	2.61	New houses	m^2	196.00		New houses	m^2	196.00	
Base Slab - Formwork	m^2	25.00	0.00	Outbuildings	m^2	239.00		Outbuildings	m^2	239.00	
Wall - Concrete	m^3	37.00	11.54	Demolition of buildings	m^3	800.00		Demolition of buildings	m^3	800.00	
Wall - Reinforcement	t	3.00	5.97								
Wall - Formwork	m^2	185.00	0.01								
Wall - Finish (Granite)	m^2	122.00	0.02								
Drainage	m	62.00	0.42								
Element 7 - Property Relocate											
New houses	m^2	196.00									
Outbuildings	m^2	239.00									
Demolition of buildings	m^3	800.00									

Materials - Option 1				Materials - Option 2				Materials - Option 3			
Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e	Item	Unit	Amount	tCO_2e
			Total tCO_2e				**Total tCO_2e**				**Total tCO_2e**
			1744.04				**1396.01**				**2685.99**

F1.7 Material transport details

Options	Trip Numbers (return)	Assumed distance (km) - Castlefinn to Belfast Docks	Unladen Journeys ($kgCO2e$)[1]	Laden Journeys ($kgCO2e$)[2]	Total ($kgCO2e$)	Total ($tCO2e$)
Option 1	894	140	122189	175168	297356	**297**
Option 2	788	140	107701	154398	262099	**262**
Option 3	706	140	96494	138332	234825	**235**

[1]Using combined emissions factor (emissions factor + Well to Tank factor) for 'Rigid >17tonnes 0% Laden' - 0.97626 $kgCO_2e/km$ (BEIS, 2022)

[2]Using combined emissions factor (emissions factor + Well to Tank factor) for 'Rigid >17tonnes 100% Laden' - 1.39955 $kgCO_2e/km$ (BEIS, 2022)

F1.8 Construction fuel usage details

Options	Fuel Usage (m^3)	Fuel Usage (Litres)	Combined conversion factor (Gasoil/Red Diesel factor + Well to Tank emissions for Gasoil/Red Diesel)	Unit of conversion factor	tCO_2e
Option 1	255	140,000	3.3911	Litres/$kgCO_2e$	**475**
Option 2	240	140,000	3.3911	Litres/$kgCO_2e$	**475**
Option 3	255	165,000	3.3911	Litres/$kgCO_2e$	**560**

Appendix G

Drawing of preferred option

Castlefinn

CASTLEFINN

River Finn

1.35m diameter culvert

1.2m diameter culvert

1.2m diameter culvert with flap valve

Twin 1m x 1.5m box culverts with flap valves

0.81m

0.75m

0.83m

0.9m

1.55m

1.35m

1.5m

1.46m

1.55m

1.23m

0.5m

2.22m

2.10m

4.62m

4.69m

5.06m

2.65m

3.96m

0.74m

0.53m

2.49m

3.38m

5.31m

4.23m

R235

Legend

- Embankment
- Wall
- Culvert
- Property relocation
- Existing Culvert / Bridge
- River reach

0 0.05 0.1 0.2 0.3 0.4 Km