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# Chapter 3

## Alternatives Considered

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### 3.1 Introduction

EIA Directive 2011/92/EU (as amended by Directive 2014/52/EU), Article 5(d) requires that the information to be provided by the developer shall include *“a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment”*. This chapter has identified the flood defence options considered during the project development and the reasons why the proposed design was chosen.

### 3.2 Study Area

The study area of the proposed development is located on the north bank and within the foreshore of the River Suir in Waterford City and is bound to the north by the existing road infrastructure and the Iarnród Éireann railway corridor serviced by the Plunkett Station, the Waterford railway station. Plunkett Station is bounded to the north by a steep rock slope which is subject to rock stabilisation works as part of the overall Waterford City Public Infrastructure Project. To the south, the railway corridor is bounded by the existing quay wall and the River Suir as shown in Plate 3.1 below. The assessment of alternatives was limited to the northern bank of the River Suir, where Plunkett Station, its associated rail infrastructure and Rice Bridge Roundabout are located.



**Plate 3.1** Study Area – View east towards Plunkett Station and Rice Bridge from the west

### 3.3 Key Constraints Identified

The constraints for the proposed Flood Defences West were identified through desk study and site surveys to determine the physical, environmental and engineering constraints which exist, and which could affect the design and progress of the proposed development. The main constraints identified are listed below and have been considered during the assessment of alternatives.

#### 3.3.1 Biodiversity

The principal ecological constraint identified was the requirement to protect and enhance the conservation objectives of the Lower River Suir Special Area of Conservation (SAC) (site code 002137). The Lower River Suir SAC supports a range of Annex II species and Annex I habitats. Benthic surveys have been undertaken to confirm the presence of habitats and species on site. Hydrodynamic modelling has been undertaken, and a Natura Impact Statement (NIS) has been prepared for the proposed development. Consultations with National Parks and Wildlife Service (NPWS), Inland Fisheries Ireland (IFI) and the Department of Housing, Local Government and Heritage regarding the application for a foreshore licence have also been carried out as part of this process.

Other Natura 2000 and designated sites within the Zone of Influence (ZOI) of the proposed development are identified in Table 3.1 below.

**Table 3.1 Designated sites within the Zone of Influence of the Proposed Development**

Designated Site [site code]	Distance from the proposed development
<b>European Sites</b>	
Lower River Suir SAC [002137]	Immediate proximity
River Barrow and River Nore SAC [002162]	9 km downstream
<b>Nationally Designated Sites</b>	
Ballyhack pNHA [000695]	14.5 km downstream
Barrow River Estuary pNHA [000698]	9 km downstream
Duncannon Sandhills pNHA [001738]	18.6 km downstream
Fiddown Island pNHA [000402]	19.3 km upstream
King's Channel pNHA [001702]	3.6 km downstream
Lower River Suir (Coolfinn, Portlaw) pNHA [000399]	12.6 km upstream
River Suir Below Carrick-on-Suir pNHA [000655]	25.1 km upstream
Tibberaghny Marshes pNHA [000411]	21.8 km upstream
Waterford Harbour pNHA [000787]	15.5 km downstream

#### 3.3.2 Hydrology

The protection of river water quality of the Lower River Suir SAC was an important consideration throughout the project design. Compliance with the requirements of the Water Framework Directive and the protection of fish populations were key considerations of the design process. Flood risks during construction and the extents of potential flood level under various scenarios during the operation of the proposed development were also important considerations. The report titled "Flood Protection West of Plunkett Station – Scoping Report" was completed in January 2020 for the proposed development, the findings of which were incorporated into the design of the proposed development.

### 3.3.3 Archaeological and Architectural Heritage

There are no Architectural Conservation Areas (ACA) within the study area or its immediate environs. Cartographic sources show evidence of a number of landing stages within the site of proposed development which protruded from the northern bank into the River Suir. Remnants of these landing stages have been identified during site inspections in 2018. These timber structures facilitated the transfer of goods from shipping to the railway. The existing quay wall along the north bank of the River Suir is a cultural heritage resource.

### 3.3.4 Soils and Geology

Geotechnical investigations have been carried out within the study area to inform of potential contaminated land issues and ground conditions / depth to rock. All soil samples within the study area were classified as non-hazardous, however, Chloride, Sulphate, Antimony, Mercury and Fluoride were indicated to exceed the inert WAC in a number of samples. Trace levels of Asbestos (<0.001%) were detected in one sample which was taken from the southern boundary of the Sallypark Industrial Estate.

### 3.3.5 Structures and Utilities

The proposed development is largely located within Córas Iompair Éireann (CIÉ) lands which are operated by Iarnród Éireann (IE). IE assets within the site of proposed development include the existing railway infrastructure, utilities, Plunkett Station, and the associated car parking area(s). IE requires that a minimum clear distance of 2.04m is maintained between the nearest rail track and any proposed structures so as not to directly impinge on the rail line itself, or its operation. In addition, it is an IE requirement that construction works must not impact the normal rail traffic. These restrictions have been considered in the design of the proposed development.

A Ground Penetrating Radar (GPR) survey was carried out in 2018 along the extent of the lands west of the Plunkett Station adjacent to the existing quay wall and river embankment. The aim of the survey was to determine the nature and condition of existing rail network services, drainage, and utilities. The location of existing facilities have been taken into consideration in the design of the proposed flood defence measures.

## 3.4 Do-Minimum Scenario

The 'Do – Minimum' Option represents the minimum intervention, which acts as the basis against which flood defence options are appraised. The Do-Minimum Option for the project would be for the existing masonry flood defence wall to remain unchanged.

The Do – Minimum Option does not meet the project objectives and is not considered to be a feasible option for the following reasons:

- The Iarnród Éireann railway line currently floods and is susceptible to future climate change induced flooding. The frequency and the extents of the flooding are likely to increase in the future and causing a significant risk to both the public transport infrastructure and public safety; and
- Sections of the existing masonry flood defence wall are in poor condition and are likely to further degrade and collapse into the river in the near future.

### 3.5 Do-Something Scenario

The Do – Something Scenario consists of the construction of flood defence measures west of the North Quays development site. The proposed development will protect Waterford’s railway station, Plunkett Station, and the associated rail infrastructure from existing and future flood risk. A number of Do-Something options are considered below.

### 3.6 Flood Defence Options Considered

The main physical constraints within the study area include the existing railway line to the north, and River Suir to the south which allow for a limited number of options to be considered as part of the assessment of alternatives. Two options, Option A and Option B were developed as part of the option selection process and are shown in Plate 3.2 below (also refer to Figures 3.1 and 3.2 in Volume 3 of this EIAR). Table 3.2 provides a description of the two options considered, both of which commence in front of Plunkett Station and continue westwards, largely parallel to the alignment of the existing quay wall.

The description of Options A and B is provided in Table 3.2 below. The design of the preferred option has been further developed since the options assessment stage, which is why the description of the proposed development in Chapter 4 of the EIAR has slightly different chainages to either of the options presented below. Further design considerations implemented for the proposed development are detailed in Section 3.9.

For the avoidance of doubt, the do-something options described in Table 3.2 below (Options A and B) were as developed for the Options Assessment stage and do not reflect subsequent design of the proposed development.

**Table 3.2 Description of Options Considered**

Chainage	Option A	Option B
0.000 to 0.270	No works are proposed at this location as part of Options A and B as the existing flood wall from Rice Bridge roundabout to Chainage 0.270 is of sufficient height (i.e., above the design flood level).	
0.270 to 0.370	<p><b><u>Remedial Works to Existing Masonry Flood Wall</u></b></p> <p>Raising of the existing masonry flood wall for c.100m to add between 0.7m and 1.3m in height is proposed as part of both options for this section due to physical constraints within the site area in the form of existing road infrastructure such as R448 Terminus Street, Rice Bridge Roundabout and R711 Dock Road. The remedial works will likely involve the construction of a reinforced concrete wall add-on and the localised repointing of the existing masonry wall. No permanent works encroachment into the Lower River Suir SAC will be necessary at this location. The majority of works are expected to be undertaken from the landside with some access required from the riverside during low tides.</p>	
0.370 to 0.520	<p><b><u>Riverside Sheet-Pile Flood Defence Wall</u></b></p> <p>Construction of approximately 150m of new flood defence wall within the Lower River Suir SAC. This section of the driven sheet pile wall will be constructed using a jack up barge from within the river. The sheet pile wall would be constructed approximately 1 metre in front of the existing quay wall in the River Suir mudflats (in the SAC) and the gap would be backfilled with clean imported granular (Class 1 or 6) earthworks fill material. The demolition of localised sections of existing masonry quay wall will also be</p>	

Chainage	Option A	Option B
	<p>required in order to connect this section of in-river sheet piles to the adjacent flood walls proposed up and down chainage.</p> <p>The reason for placing sheet piles in river in this section is due to requirements for minimum clear distance from rail tracks to the nearest structure that have to be respected according to Iarnród Éireann guidelines. The distance between the rail tracks and the existing wall is extremely tight over this section, with not enough place to fit sheet piles on the landside.</p>	
0.520 to 0.950	<p><b><u>Landside Sheet-Pile Defence Wall (nightworks)</u></b></p> <p>Construction of a sheet piled flood defence wall on land between the existing quay wall and the rail tracks, typically 1.0m behind the existing quay wall. The permanent works will not encroach into the Lower River Suir SAC. The works will be completed overnight (between 21.30 to 05.30 hours) during absolute possessions of the railway line provided by Irish Rail in order for works to have no effect on rail traffic. These reduced working hours will prolong the construction programme. Significant H&amp;S risks will exist for night-working in a tight sliver of land between rail tracks and quay wall. The realignment of Irish Rail signal ducting and the re-pointing and re-building of the sections of existing masonry wall will also be required, in order to avoid potential damage (dislodging blocks into the Lower River Suir SAC) during sheet pile wall installation and during the design life of the flood defences, as the existing quay wall is in poor condition.</p>	<p><b><u>Riverside Sheet-Pile Flood Defence Wall</u></b></p> <p>Construction of a new flood defence wall located within the Lower River Suir SAC. This section of the driven sheet pile wall will be constructed using a jack up barge. The sheet pile wall would be constructed approximately 1.0m in front of the existing quay wall in the River Suir mudflats (in SAC) and the gap would be backfilled with clean imported granular (Class 1 or 6) earthworks fill material. This would be a continuation of the sheet pile wall constructed in the 0.330 to 0.500 section using the same method. Minimal night-works and rail possessions are required. The works will simultaneously address the issue of quay wall in poor condition as the loose blocks and section will be secured by backfill.</p>
0.950 to 0.1090 and isolation structure	<p><b><u>Landside sheet piles (dayworks).</u></b> Construction of a sheet piled flood defence wall on land between the existing quay wall and the rail tracks. The works will not encroach into the Lower River Suir SAC. The works are envisaged to be undertaken during the day with a temporary fence separating the works from the railway tracks and will therefore not affect IE rail traffic, since the cess in this area is wide. The underground isolation structure across and under the rail-line at chainage Ch.1090, will be approximately 30m in length and will require nightworks and track possessions.</p>	
0.000 to 0.1090	<p><b><u>Drainage.</u></b> Upgrade of drainage system and outfalls. Replacement/ provision of flap-valves on existing and proposed back-of-wall drainage. New drainage will be limited to the relief of any trapped groundwater behind the new wall. No alteration or addition to existing land drainage is proposed.</p>	

The installation of sheet piles comprises a large part of the proposed flood defence works in both options. Other structural elements have also been considered in lieu of sheet piles at the early stage of option assessment. Earthwork bunds were ruled out due to large footprint required for them, which would result significant landtake affecting either or both the Lower River Suir SAC and or/ the Waterford to Dublin railway line. Raising the existing quay wall was ruled out due to the poor condition of the wall, which would require extensive work including demolition and replacement to achieve a sufficient wall height. The raised wall would also require a separate

underground solution to prevent groundwater flooding through deep granular layers. This would require deep temporary excavation and complex temporary works in a very constrained site, with stability risks to both quay walls and rail tracks.

Sheet piles were selected as the optimal solution as they simultaneously address both overground and underground flooding, have a very small footprint, as well as having other advantages such as cost and constructability. The small footprint of the sheet piles would have the least impact on the footprint of the Lower River Suir SAC and on unknown archaeology as it would require little to no excavation or disturbance to the mudflats within the river. The selection of sheet piles instead of the aforementioned options also requires minimal demolition works to existing structures, having the least impact on sensitive noise and air quality receptors during construction. Sheet piles are used as a state-of-the-practice solution for countless flood defences projects in Ireland and abroad.

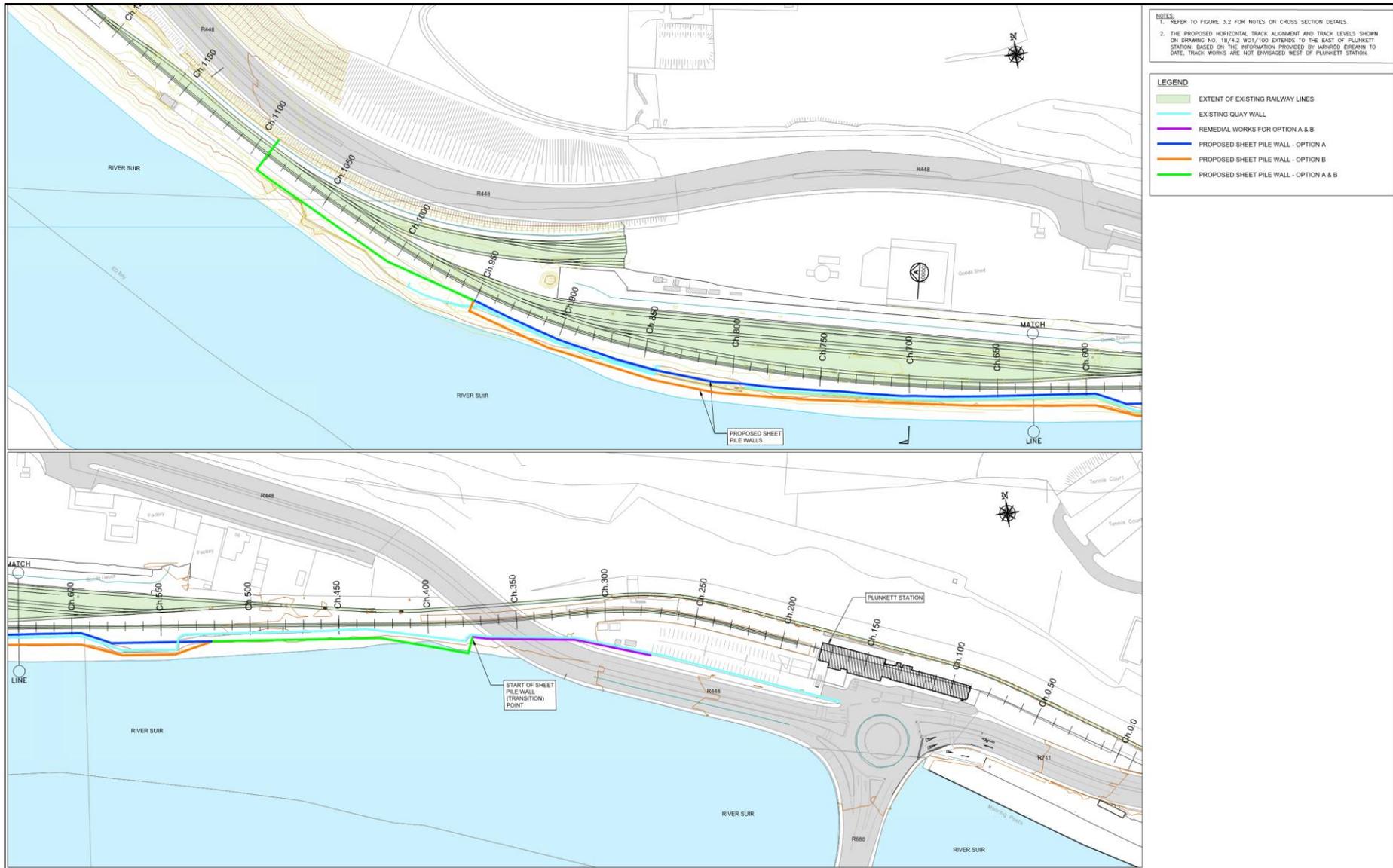


Plate 3.2 Options A and B considered for the proposed development

### 3.7 Multi-Criteria Assessment of Options Considered

A methodology was developed for the assessment of the two flood defence options considered. Options A and B were assessed in accordance with the Common Appraisal Framework (CAF) criteria of Safety, Economy, Integration, Environment, Accessibility & Social Inclusion, having regard to the associated sub-criteria outlined in the Transport Infrastructure Ireland's (TII) 'Project Appraisal Guidelines for National Roads Unit 7.0 – Multi Criteria Analysis'. The options considered were not assessed under the Physical Activity criteria as they are considered to be very similar, with the adjacent lands being either within CIÉ ownership which are not accessible to the public, or mudflats which are unsafe for public access. As such, the proposed options will not impede on any existing cycling/walking infrastructure, nor will they provide any additional infrastructure to enhance physical activity in the area. The options under each of the criteria and associated sub-criteria were subject to preference ranking outlined in Table 3.3 below.

**Table 3.3 MCA Ranking Scale**

MCA	Colour codes ranking scale
	Option has significant comparative advantage over other options
	Option has some comparative advantage over other options
	Options are comparable to each other
	Option has some comparative disadvantage over other options
	Option has significant comparative disadvantage over other options

The full Multi Criteria Analysis is provided in Appendix 3.1 of this chapter. While the two options were found to be comparable for most of the MCA criteria, the main differences arose under the following sub- criteria and are outlined in the following paragraphs:

- Under the heading of Economy:
  - Construction and Cost
  - Constructability
- Under the heading of Environment:
  - Noise and Vibration
  - Landscape and Visual
  - Biodiversity
  - Soils and Geology

#### 3.7.1 Construction and Cost

This section provides a comparative impact assessment of options under the 'Construction and Cost' sub-criteria. This sub-criteria assesses options in relation to costs associated with both permanent and temporary acquisition of land and the costs incurred for the construction of each option.

##### Option A

A larger portion of landside sheet-pile installation works (c.570m) are proposed as part of Option A and will require night works in a physically constrained sliver of land between the rail tracks and the masonry quay wall between chainages Ch.520 to

Ch.1090. This option will be more expensive than driving the sheet piles from a barge located in the river which requires a shorter construction programme.

The preliminary estimate of the total cost of sheet piling for Option A is expected to be approximately 25% more than Option B.

### **Option B**

No nightworks required or less issues with a physically constrained site are expected for Option B, however some restrictions may be required as part of the mitigation measures to be identified as part of the Environmental Impact Assessment / Appropriate Assessment. A large portion of the sheet pile wall (c.580m) will be installed from within the river using a barge. Added costs which include barge commissioning and associated work rate reduction are comparably lower than nightworks as described in Option A.

The preliminary estimate of the total cost of sheet piling for Option B is expected to be approximately 25% less than Option A.

### **Preference**

Option B has a significant advantage over Option A under the Construction and Cost MCA sub-criteria.

## **3.7.2 Constructability**

This section provides a comparative impact assessment of options under the sub-criteria of constructability.

### **Option A**

A larger portion of landside sheet-pile installation works (c.570m) are proposed as part of Option A from chainages Ch.520 to Ch.1090 (refer to Figure 3.1 in Volume 3 of this EIAR) and will require night works in a physically constrained sliver of land between the rail tracks and quay wall. This option involves increased complexity, increased interface with third parties (Iarnród Éireann) and the increased Health and Safety risks associated with night-time works in a constrained site adjacent to a tidal watercourse. This option will result in a prolonged construction period and significant technical and Health and Safety challenges for the Contractor. There is an increased risk of potential changes to design due to unexpected underground conditions being identified on site. There is a risk of destabilising the local sections of the existing quay wall where dislodged blocks may collapse into the Lower River Suir SAC. The problem of further deterioration of the existing quay wall, which is already in poor condition, is not solved using this solution which leaves it exposed; despite the intention of re-pointing the most critical areas as a part of this option.

### **Option B**

Option B involves approximately 580m of river side sheet pile installation from chainages Ch.370 to Ch.950 (refer to Figure 3.1 in Volume 3 of this EIAR). In-river works from a barge are a routine method of installation for many marine structures, including sheet piles. This option has increased time working over water with increased Health and Safety risks associated with such works. This method avoids major obstacles associated with working around night-time possessions and as currently envisaged enables uninterrupted works (note at the time of writing the options assessment - consultations with NPWS and the development of the mitigation measures in the AA/NIS may require timing restrictions on the works). Barges are readily available from operators with a local knowledge of working conditions. This

solution will prevent further deterioration of the existing quay walls and the connected risks to riverbed and mudflats.

### **Preference**

Option B has a significant advantage over Option A under the Constructability MCA sub-criteria.

### **3.7.3 Noise and Vibration**

Based on the options designs at the options selection stage, no significant difference in noise and vibration levels between options A and B was identified, except for two considerations:

- There will be comparatively more piling taking place in the river from a barge under Option B, however this will require minimal night-time works;
- Option A requires a larger section of landside sheet pile installations that will require longer night-time works.

Longer night-time works required for construction of Option A are likely to have greater impacts on sensitive receptors in comparison to Option B, where a negligible amount of night works is expected. The duration of works is also expected to be significantly longer in Option A than for Option B. The nearest residential receptor is located on the opposite side of River Suir, over 200m from the proposed options.

### **Preference**

Option B has some comparative advantage over Option A under the Noise and Vibration MCA sub-criteria.

### **3.7.4 Landscape and Visual**

This section provides a comparative impact assessment of options under the sub-criteria of landscape and visual.

Both Options are located within an urban environment, where the predominant land use is commercial/industrial in nature and as such, the landscape sensitivity of the site is considered to be low. However, Option B consists of a longer section of riverside sheet piles (c.580m) when compared to Option A which requires 150m of riverside sheet pile. Option B will be visible over larger extents along the northern bank of the River Suir, particularly at low tide from the south quays of Waterford City.

### **Preference**

Option A has some comparative advantage over Option B under the Landscape and Visual MCA sub-criteria.

### **3.7.5 Biodiversity**

The potential impacts of both options under the biodiversity sub-criteria were assessed under the headings of:

- Design-related and operational impacts;
- Construction-related impacts; and
- Cumulative impacts.

Table 3.4 below provides the comparative impact assessment of options for biodiversity.

**Table 3.4 Comparison of Options in terms of Biodiversity**

Option A	Option B
<b>Design-related and operational impacts</b>	
<p><b>Habitat loss:</b> Permanent loss of <b>c. 240 m<sup>2</sup></b> of upper intertidal mudflat (Annex I habitat type, not a qualifying interest of the SAC, important habitat for qualifying interest species Twaite Shad).</p> <p>Permanent loss of <b>c. 150 m</b> length of stone wall or other hard upper intertidal habitat, which would also result in reduced habitat heterogeneity.</p>	<p><b>Habitat loss:</b> Permanent loss of <b>c. 800 m<sup>2</sup></b> of upper intertidal mudflat (Annex I habitat type, not a qualifying interest of the SAC, important habitat for qualifying interest species Twaite Shad).</p> <p>Permanent loss of <b>c. 580 m</b> length of stone wall or other hard upper intertidal habitat, and reduced habitat heterogeneity.</p>
<p><b>Reduced habitat connectivity:</b> Constriction of the intertidal corridor by c. 1.0 m <b>over a length of c. 150 m</b> and associated reduction in the portion of the tidal cycle when there is exposed mudflat.</p>	<p><b>Reduced habitat connectivity:</b> Constriction of the intertidal corridor by c. 1.0 m <b>over a length of c. 580 m</b> and associated reduction in the portion of the tidal cycle when there is exposed mudflat.</p>
<p><b>Hydraulic impacts:</b> The presence of the flood defence structures in the river in both options will likely lead to some change in flow patterns and erosion, transport, and deposition of sediment in the vicinity of the project. While these effects have not yet been modelled, experience on projects such as the River Suir Sustainable Transport Bridge would indicate that they are very unlikely to be significant.</p>	
<b>Construction-related impacts</b>	
<p><b>Disturbance:</b> The use of barges and daytime sheet piling is likely to cause some physical and hydroacoustic disturbance to fauna in the River Suir, most notably Twaite Shad. Based on the assessments of similar impacts as carried out for other WPIP applications they are unlikely to give rise to significant effects. This is due to the pile type (sheet piles), piling method (vibration) and the location (at the edge of the river) during the daytime (when fish are active and in the centre of the channel), as well as the short duration of the works (15-25 weeks in total).</p> <p>Night-time piling from Ch.0.520 – 0.950, while on land, is sufficiently close to the river to pose a risk of significant disturbance (noise and light) to juvenile Twaite Shad, which would be less active and at the edge of the river. This disturbance may reduce the survival rate of the two age classes affected (0+ and 1+). Depending on the severity of this impact, the conservation objective for this species may be adversely affected through reduced recruitment and change in the population structure.</p> <p>Impacts on juvenile shad cannot be avoided or minimised through seasonal restrictions as they are present throughout the estuary for the full first two years of their lives.</p> <p>Other species vulnerable to disturbance from night-time piling include Otter (also a qualifying interest of the SAC) and bats.</p> <p>Due to the extended construction programme associated with nightwork constraints, the</p>	<p><b>Disturbance:</b> The disturbance impacts from this option are similar to those from Option A, except that the total <u>daytime</u> impacts occur over a longer extent and duration. However, there are <u>none</u> of the impacts associated with night-time piling.</p> <p>Daytime piling poses some risk of disturbance to nocturnal species such as Sea Lamprey which may shelter at the edge of the channel during the day during their upstream migration (April-May). Such impacts, however, can be avoided through seasonal programming of works. It is considered that such avoidance is feasible as it would leave c. 9 months available for works, while a maximum of 6 months is likely to be required.</p>

Option A	Option B
impact of disturbance from this option would occur over a longer timeframe.	
<b>Water quality:</b> Both options provide for similar risks in terms of water quality impacts arising from the use of barges and construction equipment and materials near water, disturbance of sediment from piling and repointing of damaged masonry quay walls. It is expected that water quality impacts will be mitigable and controlled using routine procedures for flood defence projects.	
<b>Invasive non-native species:</b> Both options pose a risk of the spread of invasive non-native species to, from or within the vicinity of the works. A species of particular concern in this case is Chinese Mitten Crab. This risk is slightly greater from Option B due to the greater reliance on the use of barges during construction. Either option would require the implementation of a biosecurity protocol during the construction stage.	
<b>Cumulative impacts</b>	
<b>Habitat loss:</b> Both options involve permanent habitat loss (Option B more so than Option A) in addition to habitat loss arising from other projects in the Suir-Barrow-Nore estuary. The significance of the effects of this cumulative impact will be evaluated within the Appropriate Assessment.	
<b>Increased train movements:</b> Both options will protect the existing rail infrastructure and will facilitate an increase in the number or frequency of train movements in the future, proposed as part of the SDZ Transportation Hub planning application which was granted planning permission in 2019. This poses an increased risk of direct mortality of Otter (and other animals) which might cross the railway line. However, due to the nature of the terrestrial habitats in the vicinity, the numbers of mammals, particularly otters, crossing the railway line at this location are likely to be insignificant.	
<b>Disturbance:</b> During the construction stage, disturbance from the works will likely interact with disturbance from other projects in the vicinity, e.g., the River Suir Sustainable Transport Bridge and South Plaza and the North Quays Development. Controls to ensure the effective coordination of works with potential to cause significant cumulative disturbance are already included in the planning conditions of the relevant projects and will be incorporated into the Flood Defence West assessment.	

### Consultation with Prescribed Bodies

Consultations with the National Parks & Wildlife Services (NPWS) and Inland Fisheries Ireland (IFI) were carried out in December 2020 to inform the option selection process for the proposed flood defences.

The NPWS acknowledged that both Option A and Option B provide for ecological impacts which may constitute significant effects on the conservation objectives of the Lower River Suir SAC and, therefore, that either option would likely require full appropriate assessment. The NPWS reiterated the requirements for appropriate assessment under Article 6(3) and (4) of the Habitats Directive and the precautionary principle but did not express any preference for one option over the other.

IFI also acknowledged that both options provide for likely significant impacts on fish, particularly Twaite Shad, but considered that on balance Option B could be supported as presenting the least risk of adverse effects to fish populations in the medium or long term. IFI acknowledged that Option B will result in a greater loss of the upper intertidal mudflat (Annex I) habitat compared to Option A. However, working within the railway corridor means that Option A would necessitate significantly more night-time works and, consequently, a longer construction programme and duration of disturbance. IFI also observed that night-time works for Option A would be in much closer proximity to juvenile Twaite Shad and occur when these fish ought to be inactive, which presents a risk of reduced survival rates and recruitment to the population. IFI recognised that this may constitute an adverse effect on the population structure of Twaite Shad in the SAC which would be very difficult to mitigate.

### **Preference**

Taking into consideration the biodiversity assessment of options and the feedback received from IFI and NPWS, Option A has some comparative advantage over Option B due to the reduced permanent loss of the upper intertidal mudflat (Annex I) habitat.

#### **3.7.6 Soils and Geology**

No hazardous/contaminated land has been encountered within the extents of both options based on the thorough ground testing, except at a single location where traces of asbestos were detected. Furthermore, a relatively small volume of ground will need to be excavated for both Options when compared to their overall scheme size.

However, Option B will require the construction of a larger section of riverside sheet pile wall (c.570m) in front of the existing quay wall in comparison to c.150m required for Option A. The gap between the new riverside sheet pile wall and the existing quay wall will need to be backfilled with clean granular material. As such, the import fill requirement for Option B is 3.25 times that of Option A. It is noted however that even in Option B, no more than 2,600m<sup>3</sup> of imported backfill is required, which is a very small amount for a project of this size and scope.

### **Preference**

Option A has some comparative advantage over Option B under the Soils and Geology MCA sub-criteria.

#### **3.8 Assessment Summary**

Taking into consideration the impact assessment of the proposed flood defence options under the MCA sub-criteria of land and cost, constructability noise and vibration, biodiversity and soils and geology, Option B was identified as the preferred option.

The larger extent of landside works proposed as part of Option A presented constraints both from economical, constructability and biodiversity perspectives when compared with Option B. In terms of biodiversity, the extended night-time works, and construction programme proposed as part of Option A is likely to cause disturbance to the Lower River Suir SAC over a longer period, and thus, will cause a slower recovery time. However, Option B will result in a greater habitat loss when compared with Option A.

Option A requires an installation of sheet piles from the landside over a larger area than Option B and will require longer night-time works that introduce greater complexity in terms of constructability, increased construction duration and health and safety risk. The longer night-time works required for construction of Option A are also likely to have a greater impact on noise sensitive receptors. Economically, the landside sheet piling installation over a longer distance proposed is more costly than driving sheet piles from a barge as proposed as part of Option B. Option B requires greater import of fill to backfill the gap between the new riverside sheet pile wall and the existing quay wall when compared to Option A. As such, Option A is preferred under the soils and geology sub-criteria, however the overall volumes of imported fill, and thus the significance of the impact, are very small to start with.

Option B is also seen as advantageous as it removes the risk of the existing quay wall, which is in poor condition, from collapsing into the River Suir, and avoiding any subsequent impacts to SAC over the design life of the proposed development.

Option B was therefore selected as the Preferred Option.

**Table 3.5 Options MCA Summary Assessment**

MCA Sub- Criteria	Option A	Option B
<b>Cost</b>	Significant comparative disadvantage over other options	Significant comparative advantage over other options
<b>Constructability</b>	Significant comparative disadvantage over other options	Significant comparative advantage over other options
<b>Noise and Vibration</b>	Some comparative disadvantage over other options	Some comparative advantage over option options
<b>Landscape and Visual</b>	Some comparative disadvantage over other options	Some comparative advantage over option options
<b>Biodiversity</b>	Some comparative advantage over other options	Some comparative disadvantage over other options
<b>Soils and Geology</b>	Some comparative advantage over other options	Some comparative disadvantage over other options

### 3.9 Further Design Considerations

As noted in Section 3.6, a number of design changes have been introduced to the design of the proposed development since Option B was determined as the preferred option in the option selection process. The main changes which have been made to Option B and which now form part of the design of the proposed development described in Chapter 4 of this EIAR are as follows:

- Very minor changes in the alignment of the sheet pile wall have been introduced upon further review of the existing topography, quay wall geometry and condition and other obstacles. One of these changes included the revision of the transition point between the landside and riverside sheet pile wall, from Ch.950 to Ch.900 (see Figure 4.4 in Volume 3 of this EIAR) due to the discovery of an Annex I saltmarsh habitat during April 2021 site surveys.
- The extent of the concrete wall required to be remediated was revised. Upon detailed inspection of the existing quay wall, it was found that a larger section of the quay wall was at the required design level of 4.3 mOD, and as such, the section of wall to be remediated was reduced from 100m in length to 75m.
- Inclusion of underground flood protection measures in a form of an impermeable trench in front of Plunkett Station. Measures to protect IÉ infrastructure and associated utilities from groundwater seepage were deemed necessary after reviewing further available groundwater monitoring data. The proposed underground flood protection measures in front of the Plunkett Station, together with overground measures in this area described in the next bullet point, will ensure that there is no gap between the Flood Defences West and the Flood Defences East which have been approved in 2019 as part of the Transportation Hub planning application.
- Inclusion of overground flood protection measures for the Rice Bridge Roundabout. As the surface levels of Rice roundabout and entrance to Plunkett station are slightly lower than the design flood levels, low glass flood barriers and demountable flood barriers will be set up at the verges of the roundabout as part of the proposed development.

- Drainage design and description is at a more advanced level in Chapter 4 of this EIAR compared to the options stage. However, no fundamentals were changed, and the drainage elements described as part of Options A and B have been retained. The vast majority of drainage works are the same for both options.

The design changes outlined above are stand-alone construction elements, and it is very likely that they would have been identical in Options A and B and as such, would not have affected the option selection process.



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# Appendix 3.1

## MCA Summary

### Assessment Matrix

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### APPENDIX 3.1 MCA Summary Assessment Matrix

Criteria	Parameter	Option A	Option B
Economy	1.1. Construction and Land Cost	<b>Significant comparative disadvantage over other options</b>	<b>Significant comparative advantage over other options</b>
		<p>Current cost estimate shows the construction cost of Option A to be approximately 25% more expensive than Option B. Preliminary approximate price €4.2m.</p> <p>Lands are mainly owned by CIÉ. CPO of lands not in the ownership of CIÉ or WCCC will be required. Foreshore licence will be required for development on the foreshore.</p> <p>Significant disadvantage for option A.</p>	<p>Current cost estimate shows the construction cost of Option B to be approximately 25% less expensive than Option A. Preliminary approximate price €3.2m.</p> <p>Lands are mainly owned by CIÉ. CPO of lands not in the ownership of CIÉ or WCCC will be required. Foreshore licence will be required for development on the foreshore.</p>
	1.2 Long Term Maintenance costs	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		<p>Both options involve virtually the same structure options across the same length. The selected option (sheet pile wall) will be designed to minimise the long-term maintenance costs through design decisions (sacrificial corrosion thickness, coating, and other) and achieve 120 years design life without maintenance interventions.</p> <p>Option A has slightly less exposure to elements as it has longer landside length compared to option B, but not enough to warrant any discernible difference between options in terms of maintenance.</p>	<p>Both options involve virtually the same structure options across the same length. The selected option (sheet pile wall) will be designed to minimise the long-term maintenance costs through design decisions (sacrificial corrosion thickness, coating, and other) and achieve 120 years design life without maintenance interventions.</p> <p>Option B has slightly more exposure to elements as it has longer riverside length compared to option A, but not enough to warrant any discernible difference between options in terms of maintenance.</p>
Economy	1.3 Traffic Functionality / Economic Benefit	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		<p>The development will not affect journey times as it does not interfere with any local infrastructure.</p> <p>Construction methodology will be set to have no effect to day-to-day rail traffic in the vicinity of the proposed development.</p> <p>Proposed development will have a positive benefit to rail traffic in the area by preventing the flooding that has, up to now, caused frequent temporary closures of the local rail line.</p>	<p>The development will not affect journey times as it does not interfere with any local infrastructure.</p> <p>Construction methodology will be set to have no effect to day-to-day rail traffic in the vicinity of the proposed development.</p> <p>Proposed development will have a positive benefit to rail traffic in the area by preventing the flooding that has, up to now, caused frequent temporary closures of the local rail line.</p>

Criteria	Parameter	Option A	Option B
	1.4 Constructability	<b>Significant comparative disadvantage over other options</b>	<b>Significant comparative advantage over other options</b>
		Option A involves approximately 570m of landside sheet piling works, of which more than 400m are located in a very narrow strip of land (<6m wide) between the existing quay wall and the rail tracks. This will require night-time works as absolute possession will be required from Irish Rail which can only be accommodated during night. Night-time works will raise the complexity and risks (technical and H&S) in addition to technical and logistical challenges of working in such a confined area. There is a risk of destabilising the local sections of the existing quay wall where dislodged blocks may collapse into the Lower River Suir SAC. The duration of construction is expected to be significantly longer than for Option B. In addition, option A would leave the current quay wall in poor condition exposed to flood waters.	Option B involves approximately 580m of river side sheet pile installation which is a relatively routine and straightforward way of installing similar marine structures. The works do not require any possession from Irish Rail and can be carried out during the day. The 140m of landside works will be carried out in an area with adequate clearance, enabling the works to be done behind temporary fence while keeping rail traffic open.  Option B has significant comparative advantage over Option A in this view.

Criteria	Parameter	Option A	Option B
Integration	2.1 Transport Integration	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		Both options support the overall transport integration associated with the development of a more sustainable Waterford City. No existing level crossing affected. Possessions will occur during night-time therefore no impact on rail passengers' journeys.	Both options support the overall transport integration associated with the development of a more sustainable Waterford City. No existing level crossing affected. No rail possessions will be required due to working in river therefore no impact on rail passengers' journeys.
	2.2 Land Use Integration	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		Relevant planning policy is contained in the Waterford City Development Plan 2013-2019 (as extended): The city administrative areas are zoned for Industrial use. The site is also within Flood Zone A&B. Ferrybank Belview Local Area Plan 2017 identifies relevant adjoining zoned lands as: 'BITP - Business, Industry and Technology Parks' in which there is a small area zoned for 'Community facilities'. The site is	Relevant planning policy is contained in the Waterford City Development Plan 2013-2019 (as extended): The city administrative areas are zoned for Industrial use. The site is also within Flood Zone A&B. Ferrybank Belview Local Area Plan 2017 identifies relevant adjoining zoned lands as: 'BITP - Business, Industry and Technology Parks' in which there is a small area zoned for 'Community facilities'. The site is

Criteria	Parameter	Option A	Option B
		contained with the Lower River Suir SAC and lands are zoned for 'Opportunity Sites' and 'Mixed Use'. The existing land use of the site consists of rail infrastructure, while commercial/industrial use is evident within the Sallypark industrial site which is adjacent to the railway corridor and located to the north of the proposed options.	contained within the Lower River Suir SAC. and lands are zoned for 'Opportunity Sites' and 'Mixed Use'. The existing land use of the site consists of rail infrastructure, while commercial/industrial use is evident within the Sallypark industrial site which is adjacent to the railway corridor and located to the north of the proposed options.

Criteria	Parameter	Option A	Option B
Environment	3.1 Noise and Vibration	<p><b>Some comparative disadvantage over other options</b></p> <p>Driven sheet pile walls. The vibrations to the nearby infrastructure (rail tracks and existing masonry quay wall) will be considered. Based on existing information there is not likely to be any discernible difference in noise and vibration levels between options A and B, except for two considerations. i) there will be comparatively more piling taking place in the river in Option B, and ii) the noise produced in Option A will be largely during night which has more negative impacts on the environment and any sensitive receptors in comparison to Option B, where a negligible amount of night works is expected. The duration of works is also expected to be significantly longer in option A than for Option B. The nearest residential receptor is located on the other side of river Suir, over 200m to the south.</p>	<p><b>Some comparative advantage over other options</b></p> <p>Driven sheet pile walls. The vibrations to the nearby infrastructure (rail tracks and existing masonry quay wall) will be considered. Based on existing information there is not likely to be any discernible difference in noise and vibration levels between options A and B, except for two items: i) there will be comparatively more river piling in Option B, and ii) the produced noise in Option A will be largely during night which has more adverse effects in comparison to Option B where a negligible amount of night works is expected. The nearest residential receptor is located on the other side of river Suir, over 200m to the south.</p>
	3.2 Air Quality and Climate	<p><b>Options are comparable to each other</b></p> <p>Temporary construction stage effects will be required to be considered and are not likely to be significantly different at this stage in the process.</p>	<p><b>Options are comparable to each other</b></p> <p>Temporary construction stage effects will be required to be considered and are not likely to be significantly different at this stage in the process.</p>
	3.3 Landscape and Visual (including light)	<p><b>Some comparative advantage over other options</b></p> <p>Flood defence wall will raise the top visible level of built infrastructure by between 1.0m and 1.7m, to +4.3mOD, and will be visible above the existing masonry quay wall. For 150m length, the sheet pile wall will be installed in front of the</p>	<p><b>Some comparative disadvantage over other options</b></p> <p>Flood defence wall will raise the top visible level of built infrastructure by between 1.0m and 1.7m, to +4.3mOD, and will be visible above the existing masonry quay wall. For 580m length, the sheet pile wall will be installed in front of the</p>

Criteria	Parameter	Option A	Option B
		<p>existing quay wall (riverside). Sheet piles are typical quay and flood defence systems in urban infrastructure, particularly in industrial zones such as this one, and are in keeping with landscape character. However, the riverside sheet pile walls will be more visible during low tide from the River Suir. As such, Option A has some comparative advantage over Option B by requiring a shorter section of riverside sheet piles.</p>	<p>existing quay wall (riverside). Sheet piles are typical quay and flood defence systems in urban infrastructure, particularly in industrial zones such as this one, and are in keeping with landscape character. However, the riverside sheet pile walls will be more visible during low tide from the River Suir. As such, Option B has some comparative disadvantage over Option A as it requires a longer section of riverside sheet piles which will be visible over longer extent along the north bank.</p>
	3.4 Biodiversity	<p style="text-align: center;"><b>Some comparative advantage over other options</b></p> <p>Permanent loss of intertidal mudflats (approx. 240 m<sup>2</sup>). This habitat is of a type listed on Annex I to the Habitats Directive (92/43/EEC) and the area that would be lost is within the Lower River Suir SAC. While not listed as a qualifying interest of the SAC, intertidal mudflats are critical to the achievement of the conservation objectives for Twaite Shad and other qualifying interests of the SAC. Permanent reduction in habitat connectivity along intertidal mudflat corridor due to narrowing by 1 m along 150 m length. Habitat loss and fragmentation unlikely to be mitigable in this case. This poses a risk of adverse effects on the SAC. Potential permanent reduction in habitat heterogeneity/zonation and, consequently, species diversity due to loss of upper intertidal mudflat and hard, structured, upper intertidal and splash zone habitat provided by existing quay wall. This is potentially partially mitigable in the medium term through the use of ecostructures on the new wall, though the loss of upper intertidal mudflat will not be mitigable. Likely significant cumulative effect of loss of intertidal mudflats resulting from this project, other projects in the vicinity and historic reclamation. Potential changes to sediment erosion, transport, and deposition patterns due to presence of new in-stream structure may also affect intertidal mudflats and other habitats beyond project boundary. Use of jack-up barges would cause temporary/short-term disturbance to habitats and species. Piling for the new flood defence wall would</p>	<p style="text-align: center;"><b>Some comparative disadvantage over other options</b></p> <p>Permanent loss of intertidal mudflats (approx. 800 m<sup>2</sup>). This habitat is of a type listed on Annex I to the Habitats Directive (92/43/EEC) and the area that would be lost is within the Lower River Suir SAC. While not listed as a qualifying interest of the SAC, intertidal mudflats are critical to the achievement of the conservation objectives for Twaite Shad and other qualifying interests of the SAC. Permanent reduction in habitat connectivity along intertidal mudflat corridor due to narrowing by 1 m along 580 m length. Habitat loss and fragmentation unlikely to be mitigable in this case. This poses a risk of adverse effects on the SAC. Potential permanent reduction in habitat heterogeneity/zonation and, consequently, species diversity due to loss of upper intertidal mudflat and hard, structured, upper intertidal and splash zone habitat provided by existing quay wall. This is potentially partially mitigable in the medium term through the use of ecostructures on the new wall, though the loss of upper intertidal mudflat will not be mitigable. Likely significant cumulative effect of loss of intertidal mudflats resulting from this project, other projects in the vicinity and historic reclamation. Potential changes to sediment erosion, transport, and deposition patterns due to presence of new in-stream structure may also affect intertidal mudflats and other habitats beyond project boundary. Use of jack-up barges would cause temporary/short-term disturbance to habitats and species. Piling for the new flood defence wall would</p>

Criteria	Parameter	Option A	Option B
		<p>cause hydroacoustic impacts on habitats and species, particularly Twaite Shad, which is very sensitive to noise. This impacts would be temporary and, as the piling will mainly involve sheet piles being driven by vibration at the edge of the channel, not likely be significant. As with all construction in and adjacent to waters, there is a risk of temporary/short-term water quality impacts could negatively affect aquatic ecosystems. However, given the nature and scale of the project, mitigation to effectively control this risk is feasible. The uses of vessels such as jack up barges poses a risk of the introduction or spread of invasive alien species, e.g., Chinese Mitten Crab. This risk can be effectively controlled by implementation of an appropriate biosecurity protocol. All of the operational impacts associated with Option A are the same as those for Option B, except that permanent impacts are of a lesser magnitude for Option A than for Option B. Construction-related impacts differ slightly, as follows: sheet piling on land for Option A would take place at night and would be of a slightly higher magnitude and longer duration in terms of noise impacts, which would increase potential disturbance impacts to nocturnal species and Otter when compared with Option B, but would eliminate the risk of significant impacts on the most noise-sensitive receptor, Twaite Shad. However, there is a risk of destabilising the local sections of the existing quay wall when installing the landside sheet piles, where dislodged blocks may collapse into the Lower River Suir SAC.</p>	<p>cause hydroacoustic impacts on habitats and species, particularly Twaite Shad, which is very sensitive to noise. This impacts would be temporary and, as the piling will mainly involve sheet piles being driven by vibration at the edge of the channel, not likely be significant. As with all construction in and adjacent to waters, there is a risk of temporary/short-term water quality impacts could negatively affect aquatic ecosystems. However, given the nature and scale of the project, mitigation to effectively control this risk is feasible. The uses of vessels such as jack up barges poses a risk of the introduction or spread of invasive alien species, e.g., Chinese Mitten Crab. This risk can be effectively controlled by implementation of an appropriate biosecurity protocol. All of the impacts associated with Option B are the same as those for Option A, except that permanent impacts are of a greater magnitude for Option B than for Option A. Construction-related impacts differ slightly, as follows: sheet piling into the mudflats for Option B would take place mostly during the day and would be of a slightly lower magnitude and shorter duration in terms of noise impacts, which would reduce potential disturbance impacts to nocturnal species and Otter when compared with Option A, but would increase the risk of significant impacts on the most noise-sensitive receptor, Twaite Shad.</p>
	3.5 Cultural, Archaeological and Architectural Heritage	<p style="text-align: center;"><b>Options are comparable to each other</b></p> <p>There are no protected structures, recorded historic or archaeological monuments likely to be affected by the proposed works. However, there is potential of encountering previously unrecorded underwater archaeology. Local impacts to the masonry quay wall may arise.</p>	<p style="text-align: center;"><b>Options are comparable to each other</b></p> <p>There are no protected structures, recorded historic or archaeological monuments likely to be affected by the proposed works. However, there is potential of encountering previously unrecorded underwater archaeology. Local impacts to the masonry quay wall may arise.</p>

Criteria	Parameter	Option A	Option B
	3.6 Water Resources	<p><b>Options are comparable to each other</b></p> <p>Both options will defend lands to the north against flooding up to the design flood event. As a result, flood waters will be displaced from existing area liable to flood and confined to the River Suir. The flood regime at this location is tidally dominated and the volume of the flood waters displaced by either option is negligible in the context of the tidal extents of the Suir, Barrow, Nore and Waterford Harbour. Option A will displace less flood water than option B. However, the resultant difference in flows and flood levels will be imperceptible. Potential impacts to floodplain displacement are likely imperceptible permanent and are comparable between both options.</p> <p>Both options require construction in and adjacent to the River Suir, as such there is a risk of temporary/short-term negative impacts to water quality. However, given the nature and scale of the project, mitigation of these impacts is likely feasible. The potential impact to water quality is comparable between both options.</p>	<p><b>Options are comparable to each other</b></p> <p>Both options will defend lands to the north against flooding up to the design flood event. As a result, flood waters will be displaced from existing area liable to flood and confined to the River Suir. The flood regime at this location is tidally dominated and the volume of the flood waters displaced by either option is negligible in the context of the tidal extents of the Suir, Barrow, Nore and Waterford Harbour. Option B will displace a greater volume of flood water than option A. However, the resultant difference in flows and flood levels will be imperceptible. Potential impacts to floodplain displacement are likely imperceptible permanent and are comparable between both options.</p> <p>Both options require construction in and adjacent to the River Suir, as such there is a risk of temporary/short-term negative impacts to water quality. However, given the nature and scale of the project, mitigation of these impacts is likely feasible. The potential impact to water quality is comparable between both options.</p>
	3.7 Agriculture and Non-Agricultural	<p><b>Options are comparable to each other</b></p> <p>Lands are mainly owned by CIÉ. CPO of lands not in the ownership of CIÉ or WCCC will be required. Foreshore licence will be required for development on the foreshore. No impact on either agricultural land take or property.</p>	<p><b>Options are comparable to each other</b></p> <p>Lands are mainly owned by CIÉ. CPO of lands not in the ownership of CIÉ or WCCC will be required. Foreshore licence will be required for development on the foreshore. No impact on either agricultural land take or property.</p>
	3.8 Geology and Soils (including Waste)	<p><b>Some comparative advantage over other options</b></p> <p>No hazardous/contaminated land has been encountered through ground testing, except a single location with traces of asbestos.</p> <p>Relatively small volume of ground will need to be excavated, when compared to overall scheme size. Approximately 175m<sup>3</sup> and 50m<sup>3</sup> for options A and B respectively (plus approximately 1,000m<sup>3</sup> excavation for drainage). Approximately half of the volume will go to inert WAC landfill,</p>	<p><b>Some comparative disadvantage over other options</b></p> <p>No hazardous/contaminated land has been encountered in the thorough ground testing, except a single location with traces of asbestos.</p> <p>Relatively small volume of ground will need to be excavated, when compared to overall scheme size. Approximately 175 m<sup>3</sup> and 50m<sup>3</sup> for options A and B respectively (plus approximately 1,000m<sup>3</sup> excavation for drainage). Approximately half of the volume will go to inert WAC landfill,</p>

Criteria	Parameter	Option A	Option B
		with other half to landfill that accepts the waste in excess of inert WAC limits. Option A will require approximately 800m <sup>3</sup> of imported clean granular fill to fill the gap between the sheet pile wall and existing quay wall.	with other half to landfill that accepts the waste in excess of inert WAC limits. Option B will require approximately 2,600m <sup>3</sup> of imported clean granular fill to fill the gap between the sheet pile wall and existing quay wall. Minor comparative disadvantage over Option A due to the increased volume of imported fill required in estuarine environment (SAC).

Criteria	Parameter	Option A	Option B
<b>Accessibility &amp; Social Inclusion</b>	4.1 Impact on Vulnerable Groups	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		Flood defences will enable safe, reliable rail passenger services to the population including vulnerable groups.	Flood defences will enable safe, reliable rail passenger services to the population including vulnerable groups.
	4.2 Social Inclusion	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		No change	No change

Criteria	Parameter	Option A	Option B
<b>Safety</b>	5.1 Rail Safety	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		Flood defences will enable more reliable functioning of the rail line. Both options will bring about the same level of rail safety.	Flood defences will enable more reliable functioning of the rail line. Both options will bring about the same level of rail safety.
	5.2 Vehicular Traffic Safety	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		No change	No change
	5.3 Pedestrian, Cyclist & Vulnerable Road User Safety	<b>Options are comparable to each other</b>	<b>Options are comparable to each other</b>
		No change	No change

<b>MCA Option Criteria and sub-criteria comparative colour coded ranking scale</b>
<b>Significant comparative advantage over other options</b>
<b>Some comparative advantage over other options</b>
<b>Options are comparable to each other</b>
<b>Some comparative disadvantage over other options</b>
<b>Significant comparative disadvantage over other options</b>