ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The Burrow CFERM scheme

Appendix 2D

Volume 3

The Burrow, Economic Appraisal

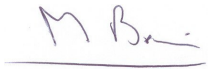
2025 Update

IBE1820
The Burrow
Economic Appraisal
D03
13 November 2025

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
D01	Final	JCA			21/06/2024
D02	2025 Update	SJ	KC	MB	27/10/2025
D03	2025 Final	SJ	KC	MB	13/11/2025

Approval for issue

Dr. M. Brian		13/11/2025

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1 INTRODUCTION

1.1 Background

In June 2024, J Chatterton Associates (JCA) were commissioned by RPS Ireland Limited (now Tetra Tech Consulting Limited) on behalf of Fingal County Council to undertake a Benefit Cost Analysis of the alleviation of flooding and the delay of coastal erosion within the Burrow associated with proposed coastal management measures. The results of this study were presented in an earlier version of this report (D01) in June 2024.

Following a review by the Office of Public Works (OPW), this report has subsequently updated to reflect a modified methodology as described in this document.

As the author of the original report (John Chatterton) retired in 2024, this report has been updated by Tetra Tech Consulting Ltd. However, the method and approach developed by JCA has remained consistent, other than incorporating the suggested amendments to eliminate flood damages associated with properties lost to erosion put forward by the OPW.

1.2 Overview

Figure 1.1 illustrates the progressive erosion of the coast under existing conditions assuming an average set back of 2m per year or 4m per year over a 50 year period. Figure 1.2 indicates the flooding extents for selected return periods (Annual Exceedance probabilities) considering the predicted increased flooding by year 50 under the Mid-Range Future Scenario (MRFS) with the coastline having retreated by 2m and 4m per year for +50years. All existing land seaward of the projected erosion lines will be vulnerable to flooding due to a decrease in elevations caused by erosion. Furthermore, erosion of the existing dune system which currently acts as a natural flood defence, in combination with rising sea levels caused by climate change, will create additional flood routes and increase the coastal flood risk to previously unaffected areas of low lying land.

Data from this analysis were used in conjunction with estimated capital and maintenance costs to prepare this economic appraisal for the proposed development.

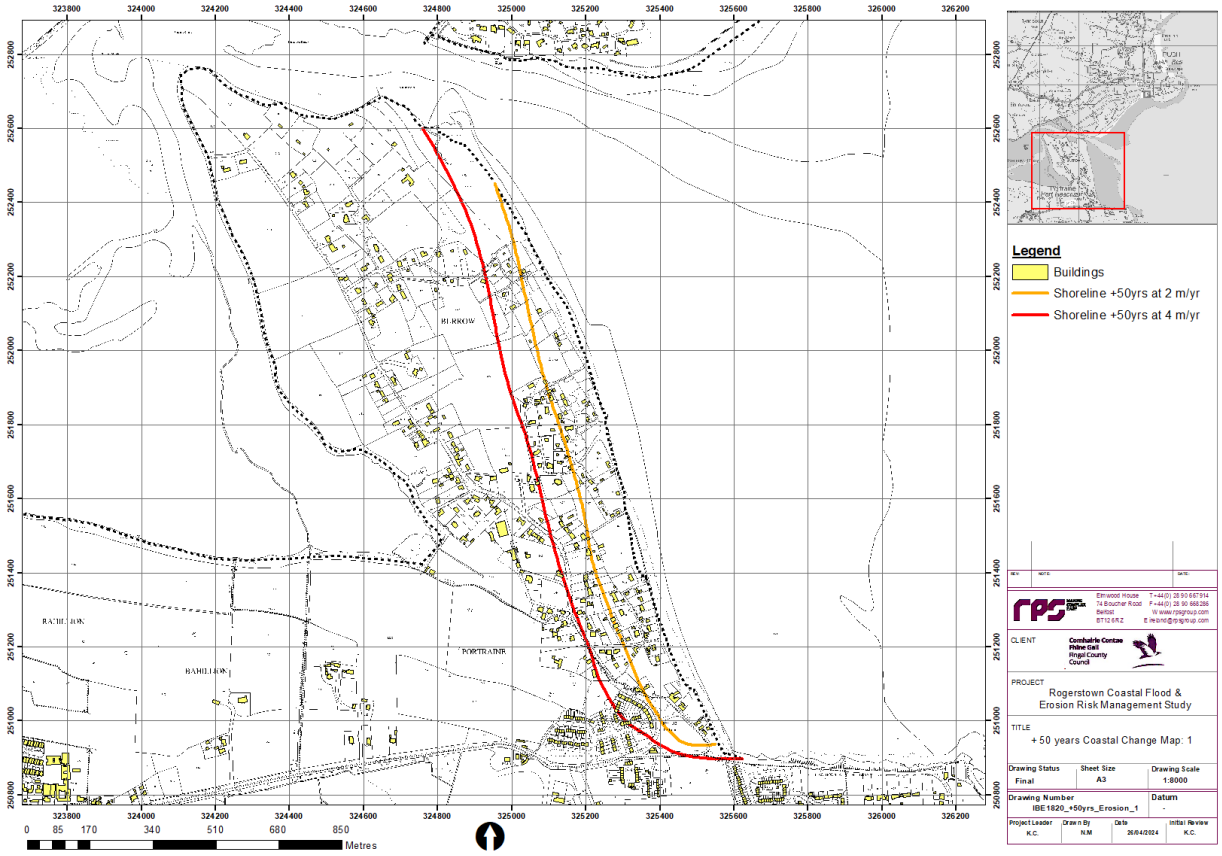
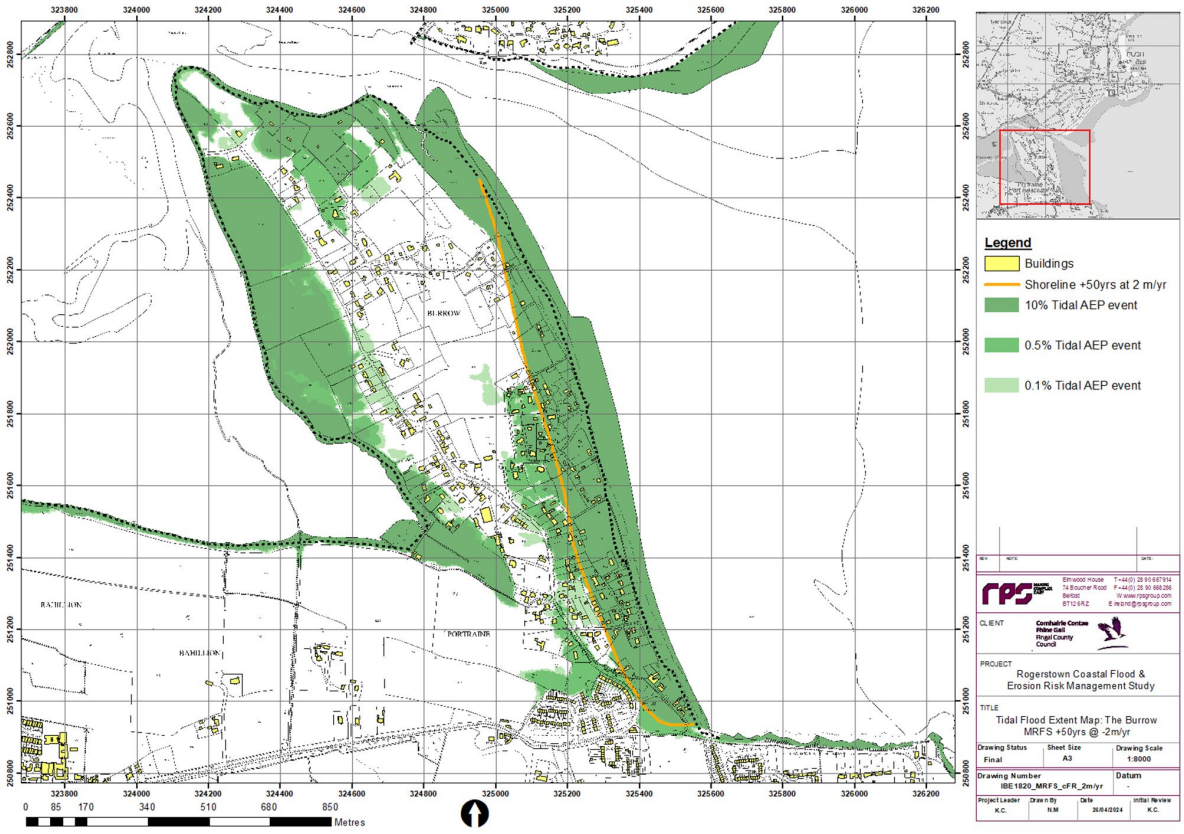


Figure 1.1: Projected coastal change across the Burrow over the next +50 years based on 2 and 4 m per year erosion scenarios



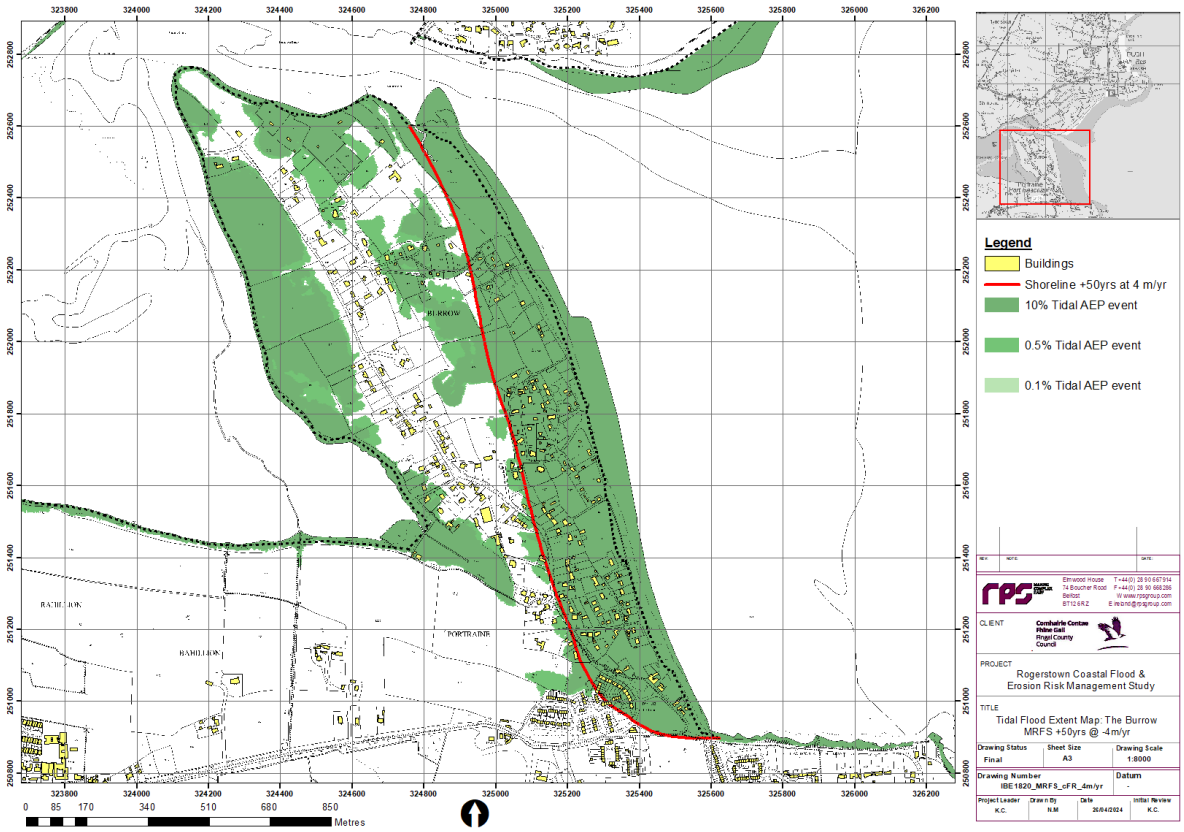


Figure 1.2: Updated Tidal Flood Extent Maps: The Burrow – MRFS (+0.25m SLR) with erosion at 2m/yr (upper) and 4 m/yr (lower) for 50yrs

1.3 Appraisal Scenarios

Table 1-1 summarises the range of scenarios investigated as part of this appraisal which follows the methodology described in the ***Economic Appraisal of Flood Relief Schemes Interim Technical Guidance Note*** as published by the Office of Public Works (OPW, 2023). Four basic scenarios were considered varying with respect to:

- Rates of erosion.
- Flooding thresholds for flooded properties.

In-line with OPW guidance and the Public Spending Code , three different discounting scenarios, as outlined below, were employed in examining the four erosion and flooding scenarios outlined above :

- 4.0% from years 0 to 30 and 3.5% thereafter to year 50.
- A flat 3% rate for 50 years.
- A flat 5% rate for 50 years.

In the interest of further examining the sensitivity of the assessment, all scenarios were considered using two property values:

- The median value of properties within Eircode K36 (Malahide) in June 2024, €520,000
- The updated median value of properties within Eircode K36 (Malahide) in September 2025, €600,000

Table 1-1: Selected Flooding and Coastal Erosion scenarios considered in this assessment.

Scenario		Test Discount Rate
A	2m/year erosion, No property flooding Threshold	3.5/4%
A3	2m/year erosion, No property flooding Threshold	3%
A5	2m/year erosion, No property flooding Threshold	5%
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%
B3	2m/year erosion, 200mm property flooding Threshold	3%
B5	2m/year erosion, 200mm property flooding Threshold	5%
C	4m/year erosion, no property flooding Threshold	3.5/4%
C3	4m/year erosion, no property flooding Threshold	3%
C5	4m/year erosion, no property flooding Threshold	5%
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%
D3	4m/year erosion, 200mm property flooding Threshold	3%
D5	4m/year erosion, 200mm property flooding Threshold	5%

1.3.1 Assumptions in the damage and loss scenarios

A summary of the assumptions used in applying the OPW appraisal guidance to the Burrow appraisal together with a commentary on the effects any changes might have on the final Net Present Value and Benefit Cost Ratio of each scenario is presented in the following Sections of this report.

1.3.2 General

The ***Multi Coloured Handbook (MCH)*** published annually by Middlesex University, London Flood Hazard Research Centre (FHRC, 2023) was the main source of method and data for this assessment. Data used for the Burrow appraisal was in line with information published on www.mcm-online.co.uk for the 2022/23.[1]

1.3.3 Currency Conversion

Conversion to Euros was made using Purchasing Power Parity (PPP) as directed in Economic Appraisal guidance note (OPW, 2023). The conversion to Euros used by for the Burrow appraisal was 1.133[2]

Although it is suggested in the guidance that inflation of prices to the cost baseline should update building fabric, inventory damage and clean up separately using appropriate wholesale and consumer price indices, this was avoided by obtaining all damage and loss data from the 2022/23 datasets.

1.3.4 Flood Duration

Long duration data (between 12 and 24 hours) was selected for flooding damage as directed in the Economic Appraisal guidance note (OPW, 2023).

1.3.5 Increasing Flood Damage due to Climate Change

The Benefit Cost Ratio (BCR) for the preferred scheme was produced for the 'Slower Onset' trajectory and was used as the primary case for the appraisal.

The 'Slower Onset', Medium Future Range Scenario (MRFS), represents a timeline that is consistent with the lower to middle range of the International Panel on Climate Change (IPCC) projections. Based on preliminary design work to date, it is envisaged that the preferred scheme which has been previously demonstrated to mitigate coastal flooding and erosion risks during a 1 in 200 year return period event with +0.25m of sea level rise will have a design life of at least 50 years.

For the purpose of this assessment, it is assumed that the sea level rise associated with the MRFS (and corresponding damages/losses) will increase linearly between years 0 and 50.

1.3.6 Residential Property Classification

Classification was based on residential property types (detached, semi-detached, terraced, bungalow, flat) with no additional precision regarding age and social class. This information was derived from a geo-directory dataset as supplied by Fingal County Council under license from Tailte Éireann.

[1] The 2023/2024 dataset only became available in mid-May 2024 and was therefore not available at the outset of this assessment.

[2] **https://www.chrislross.com/PPPConverter/**

1.3.7 Property Ground Floor Footprint

Property footprints were measured derived from geo-directory information in square metres.

1.3.8 Flooding Depth Damage

Flooding Depth Damage data adjusted for saltwater contamination was used to derive tidal flooding damage.

1.3.9 Property Floor Levels

Finished flood levels were estimated from existing Lidar information of the study area. Full property level threshold surveys were beyond the scope of this assessment. Recognising potential sensitivity issues, the following two scenarios were considered:

- No threshold level i.e., flood damage begins at the ground level as determined by Lidar survey,
- A 200mm uplift from ground level to reflect the typical raise from ground level to threshold/damp proof course level. In absence of a site-specific property threshold survey, this 200mm uplift was estimated from a review of property levels from Google Earth Street view.

1.3.10 Property Valuations

It is acknowledged that progressive coastal erosion has the potential to result in the loss of built infrastructure, including properties. As it was impractical to get detailed valuations on the many properties likely to be affected over a 50-year period, the Eircode routing key median value for K36 (Malahide) (moving 12-month median sale price February 2024) from data provided by the Central Statistical Office[3] was used to derive an approximate valuation for relevant properties.

Although the median value of €520,000 for all buyer types may appear high for The Burrow, its location near the coast and within easy commuting distance to Dublin suggested that this value could be retained. This viewpoint and approach was endorsed by Fingal County Council.

Table 1-2 summarises all of the properties sold within the vicinity of the Burrow over recent years as garnered by the Property Services Regulatory Authority. This table also notes the potential flooding status and year of loss in respect to erosion based on updated flood and erosion risk assessment undertaken by RPS. The values quoted have not been adjusted to account for inflation between time of sale and present day (i.e., 2025).

[3] House Prices interactive visualisation | CSO Ireland

Table 1-2: Property Sales in The Burrow in recent year

Sale date	Address	Eircode	Price	Years to loss (2m/year)	Flooding?
12/10/23	Sandpiper cottage	K36TD23	130.000	43	Q100
19/08/22	Meandross, The Burrow	K36PX33	750,000	295	No
22/06/21	St Finbarrs, The Burrow	K36XN66	475,000	200	No
29/06/18	Ferndale, The Burrow Rd		465,000	No data	
20/02/18	Somerset, The Burrow		420,000	190	No
28/08/15	Knocknamore, The Burrow		240,000	181	No
21/11/14	Marsh Lane, The Burrow		300,000	209	Q2 to Q100
19/09/23	Fern Meadows, The Burrow		257,000	202	Q100
08/11/12	Porters Lane, The Burrow		530,000	171	No
15/12/11	Nurses Cottage, 1 The Burrows, Strand Road		120,500	?	?
21/09/11	6 The Burrows, Strand Road		210,000	?	?
18/10/10	Sandy Dell, The Burrow		175,000	11	Q100

1.3.11 Vehicle Damage

OPW Guidance suggests an average value for a typical motor vehicle in Ireland is €16,874. However, this value was not added to each flood damaged property as:

- No data was collected on vehicle ownership.
- No allowance is made for movement of cars from flood areas before imminent flooding.

1.3.12 Residential Indirect and intangible Damages/Losses

Indirect and intangible damages/losses were considered equal to the total (direct) property flood damage or loss through flooding and/or erosion in accordance with the Economic Appraisal guidance note (OPW, 2023).

Data from www.mcm-online.ac.uk was not used to evaluate long term accommodation costs[4] following flooding as this, in effect, is already accounted for by setting indirect and intangible losses/damages equal to direct damages as described above.

1.3.13 Non-residential Properties

The Multi Coloured Handbook (MCH) categories and depth damage data per square metre were used for non-residential properties. This includes but is not limited to categories such as retail, offices, warehouses, leisure, public buildings, industry, playing fields, car parks and sub-stations.

Results from flood simulations indicated that no non-residential properties were affected by flooding for any return period (2-year AEP to 1,000-year AEP) based on the current climate scenario whilst only 2 non-residential properties were affected for the MRFS flooding scenario.

In respect of erosion risk, under the 2m per year erosion scenario, only 3 non-residential properties were considered at risk. This increased to 5 non-residential properties under the 4m per year erosion

[4] Indicative value of £5,671

scenario. Owing to a lack of detailed valuation data, these properties were given the same valuation as residential properties.

It was further assumed that there are no “unique” non-residential properties whereby a national loss could occur as a result of coastal erosion.

1.3.14 Indirect Damages to Non-Residential Properties

In general, indirect damages relate to lost earnings and profits which are deemed to be internal transfers and financial losses, rather than economic losses, and as such are excluded from the assessment of benefits. In reality, with only one non-residential property at risk from flooding indirect damages were considered inconsequential and therefore excluded from the assessment.

1.3.15 Utilities

There are no utilities (water treatment pumping stations or electricity sub stations etc) that are vulnerable to either flooding or coastal erosion.

1.3.16 Road Traffic Disruption

Traffic disruption costs have not been included in this assessment as there are very few (if any) alternative routes to properties should access be cut-off by flooding i.e. there are no alternative routes involving greater travel distances by which to evaluate the cost of travel disruption.

1.3.17 Public Realm, Amenity, Tourism, and the Environment

Whilst Chapter 8 of the MCH provides an approach to estimate the contingent valuation of a scheme, which can be significant, where an area is heavily used for recreation and tourism. However, evaluation of these potential benefits is somewhat subjective, even when based on a recreational benefits survey, as inevitable assumptions have to be made regarding how much impact the loss of a beach will have on numbers visiting. The omission of potential recreational gains and benefits mitigated by the proposed scheme results in the assessment of scheme benefits reported herein being conservative as even minimal reduction in recreational usage will have costs associated with travel to alternative venues etc.

1.3.18 Emergency Services

Costs to emergency services (which include evacuation costs) were included in the economic damages and were calculated as 8.1% of the total Residential and non-Residential flood damages in accordance with the Economic Appraisal guidance note (OPW, 2023).

1.3.19 Risk To life

As per Section 3.8.3 of the Economic Appraisal Guidance Note (OPW, 2023), the potential damage costs of loss of life in a flood event are not to be included in the assessment of economic damages given that this risk is taken into account in the option design , selection and justification for the scheme.

1.3.20 Exclusions

As per Section 4.4 of the Economic Appraisal Guidance Note (OPW, 2023), this economic assessment did not include for:

- Post scheme increases in property values.
- Future development benefits.

1.4 Calculation of Annual Average Damages (AAD) for Flooding

AADs were calculated based on a simple integration of the loss probability curve from the 50% up to the 0.1% AEP event (see Section 2, Steps 1 & 3 and associated loss probability curves in Figure 3.1 & Figure 3.2).

1.5 Calculation of Annual Average Benefits (AAB) for Flooding

AABs were calculated as the difference between damages from the 50% up to the 0.1% AEP event and the residual damages not mitigated by the proposed scheme (see Section 2, Steps 3 and 4).

1.6 Calculation of Present Value Benefits (Flooding)

The PVB associated with flooding was calculated using:

- A discount rate of 4% up to year 30, and a discount rate of 3.5% between years 31-50.
- As per the Economic Appraisal guidance note (OPW, 2023), further discount rates of 3% and 5% were used to test the sensitivity of the appraisal,
- The assessment was based on a 50 year window.

The calculation of benefits described in Section 3 and Appendices is based on the worked example detailed in Appendix C of the Economic Appraisal guidance note (OPW, 2023).

1.7 Calculation of Present Value of Benefits (Erosion)

The year to loss was used in the following formulae for all properties expected to be lost (with no protection measures). It was assumed that the scheme, if well maintained, will still be effective after year 50 (the nominal life of scheme) and erosion rates would continue to be minimal.

PV (without scheme) = MV (1 – 1 / (1 + r) p)

Where: PV = Present Value

MV = Market Value of Property

p = expected life of property with no coast protection project

r = Selected discount rate

1.8 Baseline Scenario (Flooding)

The appraisal used the “Do Nothing” (Current climate) scenario as a baseline.

1.9 Other considerations

The analysis of Present Value of Benefits (PVb) was made complex by:

- Differential rates of erosion (2 metres per year or 4 metres per year)
- Properties considered at risk of flooding which was dynamic in response to rising sea levels and the different erosion scenarios which modified potential flood routes.

Whereby properties are lost to erosion (i.e., when the coastline is within 5 metres of the property), the property no longer incurs flood damages. To account for this, the Average Annual Damage for flooding associated with a property that is lost to erosion is adjusted linearly based on year of loss. This adjusted value was then subtracted from the net Present Value of Benefits for Flooding.

The 4 metre per year erosion scenario clearly results in a more rapid loss of properties relative to the 2 metre per year scenario. Consequently and as described later in this report, the Present Value of Benefits (PVb) of alleviating flood risk for the 4 metre per year erosion scenario is therefore less than the PVb for the 2-metre erosion scenario as fewer properties remain .

A step-by-step description of the detailed economic assessment undertaken for Scenario A is presented in Section 3. Similar output is presented for the other scenarios in Appendix A - Appendix C.

1.10 Scheme costs

1.10.1 Beach nourishment and groyne scheme

Preliminary cost estimates for the coastal management scheme proposed for the Burrow which includes the construction of groynes and re-nourishing the beach with sand material were developed in 2024 based on:

- Estimates provided by experienced contractors including Ashleigh and Boskalis
- Experience from previous jobs
- Spon's Civil Engineering and Highway Works Price

A detailed breakdown of cost estimates for each element of the proposed scheme is presented in a separate spreadsheet[5], however for the purposes of informing this Economic Appraisal report, a summary of scheme costs and main assumptions are provided below:

- The initial capital cost of construction (inclusive of a 10% contractors profit margin and a 43% optimism bias) equated to €31.84 million.
- Annual maintenance of the flood embankments, flood wall and groyne structures equated to €39,021.
- The periodic beach nourishment, assumed to be required once every ten years, equated to €17.46 million.

Thus, depending on the discount rate applied (see section 1.6), the Present Value cost of the scheme over a period of 50 years equated to between **€56.30 and €67.95 million**.

It should be noted that the cost of this scheme could be *significantly* reduced should a suitable marine aggregate extraction site be identified and licensed in Ireland as opposed to importing beach nourishment material from the UK (Liverpool Bay).

1.10.2 Alternative option (Rock Armour Revetment)

An alternative option considered in the Environmental Impact Assessment Report (EIAR) involved protecting the coastline along the Burrow by constructing *c.* 1.3km rock armour revetment. Owing to the flood risk posed to other areas across the Burrow, it would still be necessary to construct the

[5] • *IBE1820 - The Burrow Preferred Scheme Cost Estimate D03.xlsx*
• *IBE1820 - The Burrow Alt1 Revetment Scheme Cost Estimate D01.xlsx*

proposed flood wall at Marsh Lane and the flood embankments which are also included in the preferred scheme.

- Based on estimates provided by a specialist contractor who is currently involved in coastal works at the Burrow, the initial capital cost of constructing the rock armour equated to €5.5 million. The total capital cost of this alternative option equated to €12.47 million. As before, this is inclusive of a 10% contractors profit margin and a 43% optimism bias.
- Annual maintenance of the flood embankments and flood wall equated to €8,849.
- The periodic maintenance of the rock armour revetment estimated at 10% of initial capital work costs once every ten years equated to €864,145.

Depending on the discount rate applied the Present Value cost of the alternative scheme over a period of 50 years equated to between **€13.80 and €14.42 million**.

2 SUMMARY OF RESULTS

Table 2-1 summarises the results from the economic appraisal (including sensitivity testing, differing Transaction Discount Rates (TDR) and property valuation assumptions) of the recommended scheme for the four scenarios.

It was found that using the €520,000 median property value gives a Benefit Cost Ratio (BCR) of greater than unity for 8 of the 12 scenarios. Increasing the typical property value to reflect the updated 2025 median value for Eircode K36 properties produced a BCR greater than unity for all scenarios except B5 (2m/year erosion, 200mm property flooding threshold).

It can therefore be concluded that based on the projected coastal flood and erosion risk posed to the Burrow over the next 50 years that the proposed scheme will, under 79% of the scenarios assessed, produce a BCR greater than unity.

Scenario B with the lower erosion rate, 200mm property threshold and most current property prices was found to produce a BCR of 1.061 under the standard TDR.

Table 2-1: Summary results for each Scenario with sensitivity analysis and both property price estimates – proposed beach nourishment and groyne scheme

			Property value - €520,000			
Scenario		Test Discount Rate	Present Value benefit (PVb) (€)	Present Value cost (PVc) (€)	Net Present Value (€)	Benefit Cost Ratio (BCR)
A	2m/year erosion, No property flooding Threshold	3.5/4%	63,449,501	58,930,067	4,519,434	1.077
A3	2m/year erosion, No property flooding Threshold	3%	77,410,688	67,946,940	9,463,748	1.139
A5	2m/year erosion, No property flooding Threshold	5%	51,677,542	56,303,933	-4,626,391	0.918
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%	55,420,176	58,930,067	-3,509,891	0.940
B3	2m/year erosion, 200mm property flooding Threshold	3%	67,481,954	67,946,940	-464,986	0.993
B5	2m/year erosion, 200mm property flooding Threshold	5%	45,240,699	56,303,933	-11,063,234	0.804
C	4m/year erosion, no property flooding Threshold	3.5/4%	123,524,693	58,930,067	64,594,626	2.096
C3	4m/year erosion, no property flooding Threshold	3%	148,765,811	67,946,940	80,818,872	2.189
C5	4m/year erosion, no property flooding Threshold	5%	102,573,562	56,303,933	46,269,628	1.822
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%	116,077,924	58,930,065	57,147,859	1.970
D3	4m/year erosion, 200mm property flooding Threshold	3%	139,516,023	67,946,940	71,569,083	2.053
D5	4m/year erosion, 200mm property flooding Threshold	5%	96,622,438	56,303,136	40,319,302	1.716

			Property value - €600,000			
Scenario		Test Discount Rate	Present Value benefit (PVb) (€)	Present Value cost (PVc) (€)	Net Present Value (€)	Benefit Cost Ratio (BCR)
A	2m/year erosion, No property flooding Threshold	3.5/4%	70,532,192	58,930,067	11,602,125	1.197
A3	2m/year erosion, No property flooding Threshold	3%	86,031,816	67,946,940	18,084,876	1.266
A5	2m/year erosion, No property flooding Threshold	5%	57,461,316	56,303,933	1,157,383	1.021
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%	62,502,867	58,930,067	3,572,800	1.061
B3	2m/year erosion, 200mm property flooding Threshold	3%	76,103,082	67,946,940	8,156,142	1.120
B5	2m/year erosion, 200mm property flooding Threshold	5%	51,024,473	56,303,933	-5,279,461	0.906
C	4m/year erosion, no property flooding Threshold	3.5/4%	139,587,642	58,930,067	80,657,575	2.369
C3	4m/year erosion, no property flooding Threshold	3%	168,089,249	67,946,940	100,142,309	2.474
C5	4m/year erosion, no property flooding Threshold	5%	115,932,065	56,303,933	59,628,132	2.059
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%	132,140,874	58,930,065	73,210,809	2.242
D3	4m/year erosion, 200mm property flooding Threshold	3%	158,839,460	67,946,940	90,892,521	2.338
D5	4m/year erosion, 200mm property flooding Threshold	5%	109,980,941	56,303,136	53,677,806	1.953

The output of the economic appraisal for the alternative scheme which would see the coastline at the Burrow protected by a *c.* 1.3km revetment as opposed to groynes and beach nourishment is summarised in Table 2-2. This alternative scheme produced a BCR of 4.484 for the 2m/yr erosion and 200m property threshold scenario under the standard TDR.

Table 2-2: Summary results for each Scenario with sensitivity analysis and both property price estimates – Alternative rock armour scheme

			Property value - €520,000			
Scenario		Test Discount Rate	Present Value benefit (PVb) (€)	Present Value cost (PVc) (€)	Net Present Value (€)	Benefit Cost Ratio (BCR)
A	2m/year erosion, No property flooding Threshold	3.5/4%	63,449,501	13,940,229	49,509,273	4.552
A3	2m/year erosion, No property flooding Threshold	3%	77,410,688	14,420,798	62,989,890	5.368
A5	2m/year erosion, No property flooding Threshold	5%	51,677,542	13,798,183	37,879,359	3.745
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%	55,420,176	13,940,229	41,479,948	3.976
B3	2m/year erosion, 200mm property flooding Threshold	3%	67,481,954	14,420,798	53,061,156	4.679
B5	2m/year erosion, 200mm property flooding Threshold	5%	45,240,699	13,798,183	31,442,516	3.279
C	4m/year erosion, no property flooding Threshold	3.5/4%	123,524,693	13,940,229	109,584,464	8.861
C3	4m/year erosion, no property flooding Threshold	3%	148,765,811	14,420,798	134,345,013	10.316
C5	4m/year erosion, no property flooding Threshold	5%	102,573,562	13,798,183	88,775,379	7.434
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%	116,077,924	13,940,228	102,137,696	8.327
D3	4m/year erosion, 200mm property flooding Threshold	3%	139,516,023	14,420,798	125,095,225	9.675
D5	4m/year erosion, 200mm property flooding Threshold	5%	96,622,438	13,798,143	82,824,294	7.003

			Property value - €600,000			
Scenario		Test Discount Rate	Present Value benefit (PVb) (€)	Present Value cost ('PVc (alt)') (€)	Net Present Value (€)	Benefit Cost Ratio (BCR)
A	2m/year erosion, No property flooding Threshold	3.5/4%	70,532,192	13,940,229	56,591,963	5.060
A3	2m/year erosion, No property flooding Threshold	3%	86,031,816	14,420,798	71,611,018	5.966
A5	2m/year erosion, No property flooding Threshold	5%	57,461,316	13,798,183	43,663,133	4.164
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%	62,502,867	13,940,229	48,562,638	4.484
B3	2m/year erosion, 200mm property flooding Threshold	3%	76,103,082	14,420,798	61,682,284	5.277
B5	2m/year erosion, 200mm property flooding Threshold	5%	51,024,473	13,798,183	37,226,290	3.698
C	4m/year erosion, no property flooding Threshold	3.5/4%	139,587,642	13,940,229	125,647,413	10.013
C3	4m/year erosion, no property flooding Threshold	3%	168,089,249	14,420,798	153,668,451	11.656
C5	4m/year erosion, no property flooding Threshold	5%	115,932,065	13,798,183	102,133,882	8.402
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%	132,140,874	13,940,228	118,200,645	9.479
D3	4m/year erosion, 200mm property flooding Threshold	3%	158,839,460	14,420,798	144,418,662	11.015
D5	4m/year erosion, 200mm property flooding Threshold	5%	109,980,941	13,798,143	96,182,798	7.971

3 STEP BY STEP ECONOMIC ASSESSMENT OF SCENARIO A

This Section provides a step-by-step overview of the methodology applied to derive the Benefit Cost Ratio (BCR) and Net Present Value (NPV) for each scenario. The following description is based on Scenario A (see Table 3-1 below) whilst the equivalent supporting calculations for Scenarios B through to D are presented in Appendices A-C of this report.

Table 3-1: Selected Flooding and Coastal Erosion scenarios

Scenario		Test Discount Rate
A	2m/year erosion, No property flooding Threshold	3.5/4%
A3	2m/year erosion, No property flooding Threshold	3%
A5	2m/year erosion, No property flooding Threshold	5%
B	2m/year erosion, 200mm property flooding Threshold	3.5/4%
B3	2m/year erosion, 200mm property flooding Threshold	3%
B5	2m/year erosion, 200mm property flooding Threshold	5%
C	4m/year erosion, no property flooding Threshold	3.5/4%
C3	4m/year erosion, no property flooding Threshold	3%
C5	4m/year erosion, no property flooding Threshold	5%
D	4m/year erosion, 200mm property flooding Threshold	3.5/4%
D3	4m/year erosion, 200mm property flooding Threshold	3%
D5	4m/year erosion, 200mm property flooding Threshold	5%

Step 1:

Derive Current Climate Annual Average Flood Damages, as shown in Table 3-2.

Table 3-2: AADs associated with flooding under current climate- Scenario A

1	Current Climate Annual Average Flood Damages (Euros) Scenarion A: No Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		799,418		
		0.004		743,700	2,975
200	0.005		687,982		
		0.005		670,224	3,351
100	0.01		652,465		
		0.01		634,168	6,342
50	0.02		615,871		
		0.03		583,284	17,499
20	0.05		550,697		
		0.05		490,313	24,516
10	0.1		429,928		
		0.1		384,756	38,476
5	0.2		339,585		
		0.3		322,507	96,752
2	0.5		305,429		
			Annual Average Damage		189,910

Step 2:

Derive Current Climate Annual Average Flood Benefits with Scheme in place as detailed in Table 3-3 and shown graphically in Figure 3.1.

Table 3-3: AADs associated with flooding with scheme in place under current climate - Scenario A

2	Current Climate Annual Average Flood Benefits (Euros)				
	No Property Thresholds -With 50 years Flood Alleviation				
Return Period (years)	Return Period Probability	Potential Damage (Euros)	Area under total Curve Total Damage	Residual Damage after scheme	Area under curve damage remaining
2	0.5	305,429			
5	0.2	339,585	96,752	-	
10	0.1	429,928	38,476	-	
20	0.05	550,697	24,516	-	
50	0.02	615,871	17,499	-	
100	0.01	652,465	6,342	-	
200	0.005	687,982	3,351	-	
1000	0.001	799,418	2,975		
			189,910		-
			Average Annual Benefits		189,910

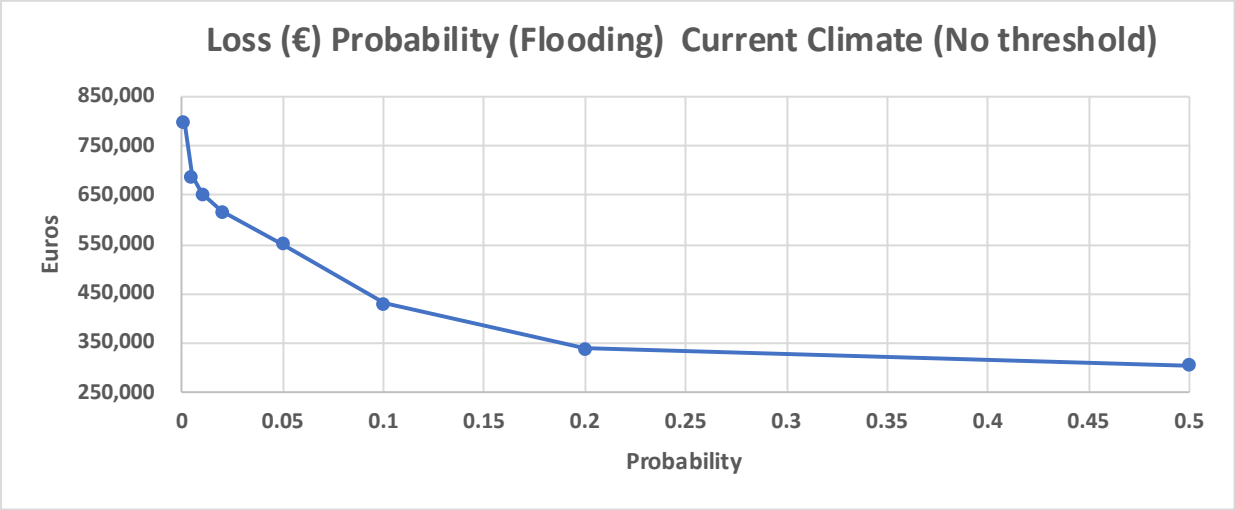


Figure 3.1: Loss Probability Curve for Current Climate – Scenario A

Step 3:

Derive Annual Average Flood Damages for the MRFS as shown in Table 3-4.

Table 3-4: AADs associated with flooding under MRFS- Scenario A

3	Mid Range Future Annual Average Flood Damages (Euros)				
	Scenario A: No Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		9,094,570		
		0.004		7,477,694	29,911
200	0.005		5,860,819		
		0.005		5,438,661	27,193
100	0.01		5,016,503		
		0.01		4,564,664	45,647
50	0.02		4,112,825		
		0.03		3,708,748	111,262
20	0.05		3,304,672		
		0.05		3,051,033	152,552
10	0.1		2,797,395		
		0.1		2,219,775	221,978
5	0.2		1,642,155		
		0.3		1,326,700	398,010
2	0.5		1,011,245		
			Annual Average Damage		986,552

Step 4:

Derive Annual Average Flood Benefits for the MRFS with scheme in place as detailed in Table 3-5 and shown graphically in Figure 3.2.

Table 3-5: AADs associated with flooding with scheme in place under current climate - Scenario A

4	Mid Range Future Annual Average Flood Benefits (Euros)				
	No Property Thresholds -With 50 years Flood Alleviation				
Return Period	Probability	Potential Damage	Area under total Curve Total Damage	Damage after scheme	Area under curve damage remaining
2	0.5	1,011,245			
5	0.2	1,642,155	398,010	-	
10	0.1	2,797,395	221,978	-	
20	0.05	3,304,672	152,552	-	
50	0.02	4,112,825	111,262	-	
100	0.01	5,016,503	45,647	-	
200	0.005	5,860,819	27,193	-	
1000	0.001	9,094,570	29,911	9,094,570	29,911
			986,552		29,911
			Average Annual Benefits		956,642

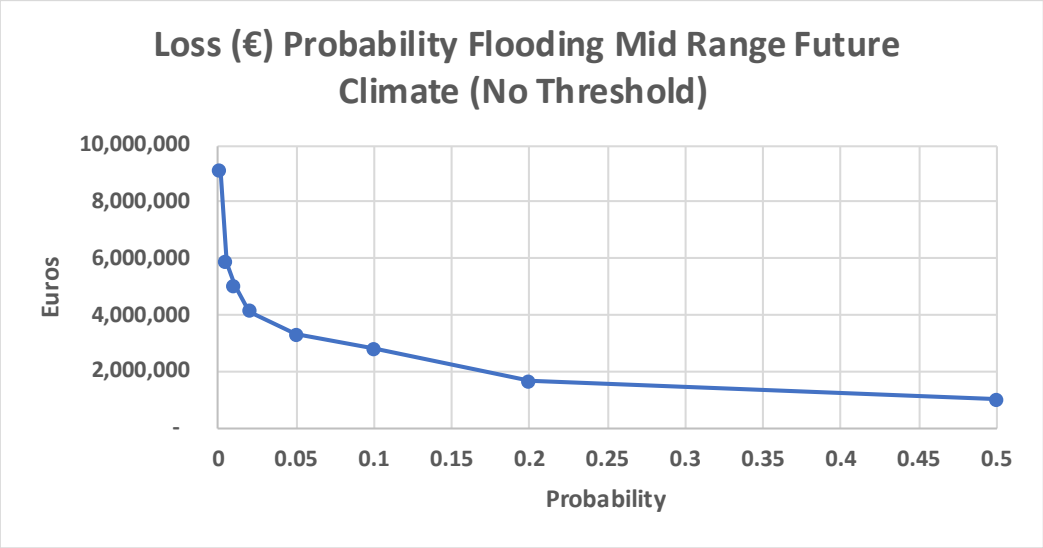


Figure 3.2: Loss Probability Curve for MRFS – Scenario A

Step 5:

Interpolate Flood Damages across the 50 year scheme life as shown in Table 3-6.

Table 3-6: PV of flooding benefits merging Current Climate with MRFS – Scenario A

5	Damages and benefits - Annualised data						
Year	Discount Rate	Curr Loss of AAD due to eroded properties	PVb Current (Current Climate)	MRFS Loss of AAD due to eroded properties	PvB MRFS Incremental Increase	Adjusted PvB	Present Value of Benefits (Linear Progression)
0	1.000	-	189,910	-	189,910	189,910	189,910
1	0.962		189,910	762	205,244	204,482	196,618
2	0.925		189,910	1,524	220,579	219,055	202,529
3	0.889		189,910	2,288	235,914	233,626	207,692
4	0.855		189,910	3,050	251,248	248,198	212,160
5	0.822		189,910	3,813	266,583	262,770	215,978
6	0.790		189,910	4,576	281,917	277,342	219,187
7	0.760		189,910	5,338	297,252	291,914	221,830
8	0.731		189,910	25,987	312,587	286,599	209,415
9	0.703		189,910	29,236	327,921	298,686	209,853
10	0.676		189,910	32,484	343,256	310,772	209,946
11	0.650		189,910	36,879	358,591	321,712	208,978
12	0.625		189,910	40,445	373,925	333,480	208,291
13	0.601		189,910	43,895	389,260	345,365	207,417
14	0.577		189,910	47,272	404,595	357,323	206,345
15	0.555		189,910	50,648	419,929	369,281	205,049
16	0.534		189,910	54,025	435,264	381,239	203,547
17	0.513		189,910	57,401	450,598	393,197	201,857
18	0.494		189,910	60,778	465,933	405,155	199,996
19	0.475		189,910	70,763	481,268	410,504	194,843
20	0.456		189,910	74,488	496,602	422,115	192,648
21	0.439		189,910	78,412	511,937	433,525	190,246
22	0.422		189,910	82,145	527,272	445,126	187,823
23	0.406		189,910	85,879	542,606	456,727	185,306
24	0.390		189,910	89,750	557,941	468,191	182,651
25	0.375		189,910	93,490	573,276	479,786	179,976
26	0.361		189,910	97,307	588,610	491,304	177,208
27	0.347		189,910	101,049	603,945	502,896	174,413
28	0.333		189,910	105,071	619,279	514,208	171,477
29	0.321		189,910	109,711	634,614	524,903	168,311
30	0.308		189,910	113,494	649,949	536,454	165,399
31	0.298		189,910	117,278	665,283	548,006	163,247
32	0.288		189,910	121,061	680,618	559,557	161,051
33	0.278		189,910	124,844	695,953	571,109	158,817
34	0.269		189,910	141,861	711,287	569,426	152,995
35	0.260		189,910	168,664	726,622	557,958	144,844
36	0.251		189,910	173,483	741,957	568,474	142,583
37	0.242		189,910	178,302	757,291	578,990	140,310
38	0.234		189,910	184,052	772,626	588,574	137,809
39	0.226		189,910	188,896	787,961	599,065	135,522
40	0.219		189,910	196,412	803,295	606,883	132,648
41	0.211		189,910	203,236	818,630	615,394	129,960
42	0.204		189,910	212,363	833,964	621,602	126,832
43	0.197		189,910	235,737	849,299	613,562	120,958
44	0.190		189,910	241,219	864,634	623,414	118,744
45	0.184		189,910	246,702	879,968	633,267	116,542
46	0.178		189,910	252,184	895,303	643,119	114,352
47	0.172		189,910	298,341	910,638	612,297	105,190
48	0.166		189,910	304,801	925,972	621,171	103,106
49	0.160		189,910	326,300	941,307	615,007	98,631
50	0.155		189,910	343,741	956,642	612,901	94,969
						PVb Floodir	**8,706,007**
						PVb Erosior	**23,018,744**
						Total PVb	**31,724,751**

A summary of the number of properties contributing to these damages is presented in Table 3-7.

Table 3-7: Summary of flooded properties for current and MRFS climate scenarios based on an erosion rate of 2 m per year

Flooded properties	# current climate	# MRFS climate
1000 year	9	94
200 year	8	62
100 year	8	54
50 year	8	44
20 year	8	37
10 year	6	34
5 year	5	22
2 year	5	16

Step 6:

Derive the benefits associated with the scheme under the 2 m/yr erosion scenario as listed in Table 3-8.

Table 3-8: PV of benefits associated with Scenario A

	Euros
PVb Flooding	8,706,007
PVb Property Erosion Loss	23,018,744
Total PVb	31,724,751

Note that flood alleviation benefits relate to a reduction in flooding assuming a scheme design life of 50 years and a linear increase between damages avoided for current climate and MRFS.

Properties lost to erosion in the 2 m/yr and 4 m/yr scenarios are accounted for in flood damage avoided scenarios as relevant using the approach outlined in Section 1.9. The numbers of properties lost due to erosion over various epochs under the 2m/yr scenario are listed in Table 3-9.

Table 3-9: Successive properties lost to erosion up to year 50 based on an erosion rate of 2 m per year

Properties lost by erosion	Number
By Year 10	16
By year 20	30
By Year 30	55
By Year 40	83
By Year 50	113

Step 7:

Undertake a sensitivity analyses of Discount Rate in accordance with the OPW Economic Appraisal guidance note, (OPW, 2023) that advises examining the sensitivity of PVb using 3% and 5% test discount rates as summarised in Table 3-10 and Table 3-11 below.

Table 3-10: PVb sensitivity testing with 3% discount code – Scenarios A - D

3% Discount rate sensitivity			
Scenario A: No scheme Current Climate		Scenario B: No scheme Current Climate	
No property threshold; 2m per year erosion		200mm Property Threshold; 2m per year erosion	
	Euros		Euros
PVb Flooding	10,686,678	PVb Flooding	5,722,311
PVb Property Erosion Loss	28,018,666	PVb Property Erosion Loss	28,018,666
Total PVb	38,705,344	Total PVb	33,740,977
Scenario C: No scheme Current Climate		Scenario D: No scheme Current Climate	
No Property Threshold; 4m per year erosion		200mm Property Threshold; 4m per year erosion	
	Euros		Euros
PVb Flooding	11,581,734	PVb Flooding	6,956,840
PVb Property Erosion Loss	62,801,171	PVb Property Erosion Loss	62,801,171
Total PVb	74,382,906	Total PVb	69,758,011

Table 3-11: PVb sensitivity testing with 5% discount code – Scenarios A - D

5% Discount rate sensitivity			
Scenario A: No scheme Current Climate		Scenario B: No scheme Current Climate	
No property threshold; 2m per year erosion		200mm Property Threshold; 2m per year erosion	
	Euros		Euros
PVb Flooding	7,041,507	PVb Flooding	3,823,085
PVb Property Erosion Loss	18,797,264	PVb Property Erosion Loss	18,797,264
Total PVb	25,838,771	Total PVb	22,620,349
Scenario C: No scheme Current Climate		Scenario D: No scheme Current Climate	
No Property Threshold; 4m per year erosion		200mm Property Threshold; 4m per year erosion	
	Euros		Euros
PVb Flooding	7,871,644	PVb Flooding	4,896,082
PVb Property Erosion Loss	43,415,137	PVb Property Erosion Loss	43,415,137
Total PVb	51,286,781	Total PVb	48,311,219

Step 8:

The final step is matching the Present Value of Benefits with the Present Value of Costs to derive the Benefit Cost Ratio and the Net Present Value (Base TDR[6], 3% & 5%) as shown in Table 3-12 and Table 3-13.

Table 3-12: PVc vs PVb and resultant BCR for discount Scenario A (left) and A3 (right)

Scenario A Base 2m/year erosion, No property flooding Threshold				
Test Discount Rates				
0 to 30yrs	4%	31 to 50 yrs	3.5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.962		39,021	37,520
2	0.925		39,021	36,077
3	0.889		39,021	34,689
4	0.855		39,021	33,355
5	0.822		39,021	32,072
6	0.790		39,021	30,839
7	0.760		39,021	29,653
8	0.731		39,021	28,512
9	0.703		39,021	27,415
10	0.676		17,455,199	11,792,107
11	0.650		39,021	25,347
12	0.625		39,021	24,372
13	0.601		39,021	23,435
14	0.577		39,021	22,533
15	0.555		39,021	21,667
16	0.534		39,021	20,833
17	0.513		39,021	20,032
18	0.494		39,021	19,262
19	0.475		39,021	18,521
20	0.456		17,455,199	7,966,325
21	0.439		39,021	17,124
22	0.422		39,021	16,465
23	0.406		39,021	15,832
24	0.390		39,021	15,223
25	0.375		39,021	14,637
26	0.361		39,021	14,074
27	0.347		39,021	13,533
28	0.333		39,021	13,013
29	0.321		39,021	12,512
30	0.235		17,455,199	4,097,272
31	0.224		39,021	8,723
32	0.213		39,021	8,308
33	0.203		39,021	7,912
34	0.193		39,021	7,535
35	0.184		39,021	7,177
36	0.175		39,021	6,835
37	0.167		39,021	6,509
38	0.159		39,021	6,199
39	0.151		39,021	5,904
40	0.144		17,455,199	2,515,369
41	0.137		39,021	5,355
42	0.131		39,021	5,100
43	0.124		39,021	4,857
44	0.119		39,021	4,626
45	0.113		39,021	4,406
46	0.108		39,021	4,196
47	0.102		39,021	3,996
48	0.098		39,021	3,806
49	0.093		39,021	3,625
50	0.155			0
			Total Present Value of Costs	58,930,067
			Total Present Value of Benefits	31,724,751
			Total PVb plus intangibles	63,449,501
			Benefit Cost Ratio	1.077
			Net Present Value	4,519,434

A3 2m/year erosion, No property flooding Threshold				
Test Discount Rates				
0 to 30yrs	3%	31 to 50 yrs	3%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.971		39,021	37,884
2	0.943		39,021	36,781
3	0.915		39,021	35,709
4	0.888		39,021	34,669
5	0.863		39,021	33,660
6	0.837		39,021	32,679
7	0.813		39,021	31,727
8	0.789		39,021	30,803
9	0.766		39,021	29,906
10	0.744		17,455,199	12,988,307
11	0.722		39,021	28,189
12	0.701		39,021	27,368
13	0.681		39,021	26,571
14	0.661		39,021	25,797
15	0.642		39,021	25,046
16	0.623		39,021	24,316
17	0.605		39,021	23,608
18	0.587		39,021	22,921
19	0.570		39,021	22,253
20	0.554		17,455,199	9,664,520
21	0.538		39,021	20,976
22	0.522		39,021	20,365
23	0.507		39,021	19,771
24	0.492		39,021	19,196
25	0.478		39,021	18,637
26	0.464		39,021	18,094
27	0.450		39,021	17,567
28	0.437		39,021	17,055
29	0.424		39,021	16,558
30	0.412		17,455,199	7,191,311
31	0.400		39,021	15,608
32	0.388		39,021	15,153
33	0.377		39,021	14,712
34	0.366		39,021	14,283
35	0.355		39,021	13,867
36	0.345		39,021	13,463
37	0.335		39,021	13,071
38	0.325		39,021	12,691
39	0.316		39,021	12,321
40	0.307		17,455,199	5,351,011
41	0.298		39,021	11,614
42	0.289		39,021	11,275
43	0.281		39,021	10,947
44	0.272		39,021	10,628
45	0.264		39,021	10,319
46	0.257		39,021	10,018
47	0.249		39,021	9,726
48	0.242		39,021	9,443
49	0.235		39,021	9,168
50	0.228			0
			Total Present Value of Costs	67,946,940
			Total Present Value of Benefits	38,705,344
			Total PVb plus intangibles	77,410,688
			Benefit Cost Ratio	1.139
			Net Present Value	9,463,748

[6] TDR = Transaction Discount Rate

Table 3-13: PVc vs PVb and resultant BCR for discount Scenario A5

A5 2m/year erosion, No property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	5%	31 to 50 yrs	5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.952		39,021	37,163
2	0.907		39,021	35,393
3	0.864		39,021	33,708
4	0.823		39,021	32,102
5	0.784		39,021	30,574
6	0.746		39,021	29,118
7	0.711		39,021	27,731
8	0.677		39,021	26,411
9	0.645		39,021	25,153
10	0.614		17,455,199	10,715,978
11	0.585		39,021	22,815
12	0.557		39,021	21,728
13	0.530		39,021	20,694
14	0.505		39,021	19,708
15	0.481		39,021	18,770
16	0.458		39,021	17,876
17	0.436		39,021	17,025
18	0.416		39,021	16,214
19	0.396		39,021	15,442
20	0.377		17,455,199	6,578,681
21	0.359		39,021	14,006
22	0.342		39,021	13,339
23	0.326		39,021	12,704
24	0.310		39,021	12,099
25	0.295		39,021	11,523
26	0.281		39,021	10,974
27	0.268		39,021	10,452
28	0.255		39,021	9,954
29	0.243		39,021	9,480
30	0.231		17,455,199	4,038,739
31	0.220		39,021	8,599
32	0.210		39,021	8,189
33	0.200		39,021	7,799
34	0.190		39,021	7,428
35	0.181		39,021	7,074
36	0.173		39,021	6,737
37	0.164		39,021	6,416
38	0.157		39,021	6,111
39	0.149		39,021	5,820
40	0.142		17,455,199	2,479,436
41	0.135		39,021	5,279
42	0.129		39,021	5,027
43	0.123		39,021	4,788
44	0.117		39,021	4,560
45	0.111		39,021	4,343
46	0.106		39,021	4,136
47	0.101		39,021	3,939
48	0.096		39,021	3,752
49	0.092		39,021	3,573
50	0.087			0
			Total Present Value of Costs	**56,303,933**
			Total Present Value of Benefits	**25,838,771**
			Total PVb plus intangibles	**51,677,542**
			Benefit Cost Ratio	**0.918**
			Net Present Value	**-4,626,391**

Appendices

Appendix A Scenario B, 200mm Flooding Threshold and 2 metres per year erosion

Step 1: Current Climate Annual Average Flood Damages

Table A-14: AADs associated with flooding under current climate- Scenario B

1	Current Climate Annual Average Flood Damages (Euros)				
	Scenarion A: 200m thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		667,489		
		0.004		593,741	2,375
200	0.005		519,993		
		0.005		470,177	2,351
100	0.01		420,360		
		0.01		388,289	3,883
50	0.02		356,217		
		0.03		332,363	9,971
20	0.05		308,509		
		0.05		292,815	14,641
10	0.1		277,121		
		0.1		254,908	25,491
5	0.2		232,694		
		0.3		221,240	66,372
2	0.5		209,787		
			Annual Average Damage		125,083

Step 2: Current Climate Annual Average Flood Benefits with Scheme

Table A-15: AADs associated with flooding post scheme under current climate- Scenario B

2	Current Climate Annual Average Flood Benefits (Euros)				
	200mm Property Thresholds -With 50 years Flood Alleviation				
Return Period (years)	Return Period Probability	Potential Damage (Euros)	Area under total Curve Total Damage	Residual Damage after scheme	Area under curve damage remaining
2	0.5	209,787			
5	0.2	232,694	66,372	-	
10	0.1	277,121	25,491	-	
20	0.05	308,509	14,641	-	
50	0.02	356,217	9,971	-	
100	0.01	420,360	3,883	-	
200	0.005	519,993	2,351	-	
1000	0.001	667,489	2,375		
			125,083		-
			Average Annual Benefits		125,083

Step 3: MRFS Annual Average Flood Damages

Table A-16: AADs associated with flooding under MRFS - Scenario B

3	Mid Range Future Annual Average Flood Damages (Euros)				
	Scenario A: 200mm Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		6,053,741		
		0.004		4,999,695	19,999
200	0.005		3,945,649		
		0.005		3,614,348	18,072
100	0.01		3,283,047		
		0.01		2,925,485	29,255
50	0.02		2,567,924		
		0.03		2,071,765	62,153
20	0.05		1,575,607		
		0.05		1,259,171	62,959
10	0.1		942,734		
		0.1		797,662	79,766
5	0.2		652,590		
		0.3		541,429	162,429
2	0.5		430,268		
			Annual Average Damage		434,632

Step 4: MRFS Annual Average Flood Benefits with scheme

Table A-17: AADs associated with flooding with scheme in place under current climate - Scenario B

4	Mid Range Future Annual Average Flood Benefits (Euros)				
	200mm Property Thresholds -With 50 years Flood Alleviation				
Return Period	Probability	Potential Damage	Area under total Curve Total Damage	Damage after scheme	Area under curve damage remaining
2	0.5	430,268			
5	0.2	652,590	162,429	-	
10	0.1	942,734	79,766	-	
20	0.05	1,575,607	62,959	-	
50	0.02	2,567,924	62,153	-	
100	0.01	3,283,047	29,255	-	
200	0.005	3,945,649	18,072	-	
1000	0.001	6,053,741	19,999	6,053,741	19,999
			434,632		19,999
			Average Annual Benefits		414,633

Step 5: Interpolation of Flood Damages

Table A-18: PV of flooding benefits merging Current Climate with MRFS – Scenario B

5	Damages and benefits - Annualised data						
Year	Discount Rate	Curr Loss of AAD due to eroded properties	PVb Current (Current Climate)	MRFS Loss of AAD due to eroded properties	PvB MRFS Incremental Increase	Adjusted PvB	Present Value of Benefits (Linear Progression)
0	1.000	-	125,083	-	125,083	125,083	125,083
1	0.962		125,083	147	130,874	130,728	125,700
2	0.925		125,083	294	136,665	136,372	126,083
3	0.889		125,083	440	142,456	142,016	126,252
4	0.855		125,083	587	148,247	147,660	126,221
5	0.822		125,083	734	154,038	153,304	126,005
6	0.790		125,083	881	159,829	158,949	125,619
7	0.760		125,083	1,027	165,620	164,593	125,077
8	0.731		125,083	7,787	171,411	163,624	119,559
9	0.703		125,083	8,760	177,202	168,442	118,345
10	0.676		125,083	9,733	182,993	173,260	117,048
11	0.650		125,083	10,821	188,784	177,963	115,601
12	0.625		125,083	11,835	194,575	182,740	114,139
13	0.601		125,083	12,822	200,366	187,545	112,634
14	0.577		125,083	13,808	206,157	192,349	111,077
15	0.555		125,083	14,794	211,948	197,154	109,473
16	0.534		125,083	15,781	217,739	201,959	107,827
17	0.513		125,083	16,767	223,530	206,763	106,147
18	0.494		125,083	17,753	229,321	211,568	104,436
19	0.475		125,083	19,591	235,112	215,521	102,295
20	0.456		125,083	20,622	240,903	220,281	100,533
21	0.439		125,083	21,676	246,694	225,018	98,746
22	0.422		125,083	22,708	252,485	229,777	96,956
23	0.406		125,083	23,740	258,276	234,536	95,157
24	0.390		125,083	24,789	264,067	239,279	93,348
25	0.375		125,083	25,821	269,858	244,037	91,542
26	0.361		125,083	26,854	275,649	248,795	89,738
27	0.347		125,083	27,887	281,440	253,553	87,936
28	0.333		125,083	28,955	287,231	258,276	86,129
29	0.321		125,083	30,078	293,022	262,944	84,313
30	0.308		125,083	31,115	298,813	267,698	82,536
31	0.298		125,083	32,153	304,604	272,452	81,161
32	0.288		125,083	33,190	310,395	277,205	79,785
33	0.278		125,083	34,227	316,186	281,959	78,409
34	0.269		125,083	37,010	321,977	284,967	76,566
35	0.260		125,083	40,620	327,768	287,148	74,543
36	0.251		125,083	41,780	333,559	291,779	73,183
37	0.242		125,083	42,941	339,350	296,409	71,831
38	0.234		125,083	44,199	345,141	300,942	70,463
39	0.226		125,083	45,362	350,932	305,570	69,127
40	0.219		125,083	46,860	356,723	309,863	67,728
41	0.211		125,083	48,181	362,514	314,333	66,381
42	0.204		125,083	49,945	368,305	318,360	64,958
43	0.197		125,083	53,615	374,096	320,481	63,180
44	0.190		125,083	54,862	379,887	325,025	61,909
45	0.184		125,083	56,109	385,678	329,569	60,651
46	0.178		125,083	57,356	391,469	334,113	59,408
47	0.172		125,083	64,999	397,260	332,261	57,081
48	0.166		125,083	66,382	403,051	336,669	55,883
49	0.160		125,083	69,018	408,842	339,824	54,499
50	0.155		125,083	72,310	414,633	342,323	53,043
						PVb Flooding	**4,691,344**
						PVb Erosion (2m)	**23,018,744**
						Total PVb	**27,710,088**

Table A-19: Summary of flooded properties for current and MRFS climate scenarios based on an erosion rate of 2 m per year

Flooded properties	# current climate	# MRFS climate
1000 year	8	70
200 year	8	44
100 year	6	39
50 year	6	35
20 year	5	28
10 year	4	17
5 year	4	11
2 year	3	8

Step 6: Benefits with the 2 m/yr erosion scenario

Table A-20: PV of benefits associated with Scenario B

	Euros
PVb Flooding	4,691,344
PVb Property Erosion Loss	23,018,744
Total PVb	27,710,088

Table A-21: Successive properties lost to erosion up to year 50 based on an erosion rate of 2 m per year

Properties lost by erosion	Number
By Year 10	16
By year 20	30
By Year 30	55
By Year 40	83
By Year 50	113

Step 7: Sensitivity Analyses of Discount Rate

See Section 3, Step 7.

Step 8: Present Value of Benefits vs Present Value of Costs

See overleaf.

Table A-22: PVc vs PVb and resultant BCR for discount Scenario B (left) and B3 (right)

B base 2m/year erosion, 200mm property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	4%	31 to 50 yrs	3.5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.962		39,021	37,520
2	0.925		39,021	36,077
3	0.889		39,021	34,689
4	0.855		39,021	33,355
5	0.822		39,021	32,072
6	0.790		39,021	30,839
7	0.760		39,021	29,653
8	0.731		39,021	28,512
9	0.703		39,021	27,415
10	0.676		17,455,199	11,792,107
11	0.650		39,021	25,347
12	0.625		39,021	24,372
13	0.601		39,021	23,435
14	0.577		39,021	22,533
15	0.555		39,021	21,667
16	0.534		39,021	20,833
17	0.513		39,021	20,032
18	0.494		39,021	19,262
19	0.475		39,021	18,521
20	0.456		17,455,199	7,966,325
21	0.439		39,021	17,124
22	0.422		39,021	16,465
23	0.406		39,021	15,832
24	0.390		39,021	15,223
25	0.375		39,021	14,637
26	0.361		39,021	14,074
27	0.347		39,021	13,533
28	0.333		39,021	13,013
29	0.321		39,021	12,512
30	0.235		17,455,199	4,097,272
31	0.224		39,021	8,723
32	0.213		39,021	8,308
33	0.203		39,021	7,912
34	0.193		39,021	7,535
35	0.184		39,021	7,177
36	0.175		39,021	6,835
37	0.167		39,021	6,509
38	0.159		39,021	6,199
39	0.151		39,021	5,904
40	0.144		17,455,199	2,515,369
41	0.137		39,021	5,355
42	0.131		39,021	5,100
43	0.124		39,021	4,857
44	0.119		39,021	4,626
45	0.113		39,021	4,406
46	0.108		39,021	4,196
47	0.102		39,021	3,996
48	0.098		39,021	3,806
49	0.093		39,021	3,625
50	0.155			0
			Total Present Value of Costs	58,930,067
			Total Present Value of Benefits	27,710,088
			Total PVb plus intangibles	55,420,176
			Benefit Cost Ratio	0.940
			Net Present Value	-3,509,891

B3 2m/year erosion, 200mm property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	3%	31 to 50 yrs	5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.971		39,021	37,884
2	0.943		39,021	36,781
3	0.915		39,021	35,709
4	0.888		39,021	34,669
5	0.863		39,021	33,660
6	0.837		39,021	32,679
7	0.813		39,021	31,727
8	0.789		39,021	30,803
9	0.766		39,021	29,906
10	0.744		17,455,199	12,988,307
11	0.722		39,021	28,189
12	0.701		39,021	27,368
13	0.681		39,021	26,571
14	0.661		39,021	25,797
15	0.642		39,021	25,046
16	0.623		39,021	24,316
17	0.605		39,021	23,608
18	0.587		39,021	22,921
19	0.570		39,021	22,253
20	0.554		17,455,199	9,664,520
21	0.538		39,021	20,976
22	0.522		39,021	20,365
23	0.507		39,021	19,771
24	0.492		39,021	19,196
25	0.478		39,021	18,637
26	0.464		39,021	18,094
27	0.450		39,021	17,567
28	0.437		39,021	17,055
29	0.424		39,021	16,558
30	0.412		17,455,199	7,191,311
31	0.400		39,021	15,608
32	0.388		39,021	15,153
33	0.377		39,021	14,712
34	0.366		39,021	14,283
35	0.355		39,021	13,867
36	0.345		39,021	13,463
37	0.335		39,021	13,071
38	0.325		39,021	12,691
39	0.316		39,021	12,321
40	0.307		17,455,199	5,351,011
41	0.298		39,021	11,614
42	0.289		39,021	11,275
43	0.281		39,021	10,947
44	0.272		39,021	10,628
45	0.264		39,021	10,319
46	0.257		39,021	10,018
47	0.249		39,021	9,726
48	0.242		39,021	9,443
49	0.235		39,021	9,168
50	0.228			0
			Total Present Value of Costs	67,946,940
			Total Present Value of Benefits	33,740,977
			Total PVb plus intangibles	67,481,954
			Benefit Cost Ratio	0.993
			Net Present Value	-464,986

Table A-23: PVc vs PVb and resultant BCR for discount Scenario B5

B5 2m/year erosion, 200mm property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	5%	31 to 50 yrs	5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.952		39,021	37,163
2	0.907		39,021	35,393
3	0.864		39,021	33,708
4	0.823		39,021	32,102
5	0.784		39,021	30,574
6	0.746		39,021	29,118
7	0.711		39,021	27,731
8	0.677		39,021	26,411
9	0.645		39,021	25,153
10	0.614		17,455,199	10,715,978
11	0.585		39,021	22,815
12	0.557		39,021	21,728
13	0.530		39,021	20,694
14	0.505		39,021	19,708
15	0.481		39,021	18,770
16	0.458		39,021	17,876
17	0.436		39,021	17,025
18	0.416		39,021	16,214
19	0.396		39,021	15,442
20	0.377		17,455,199	6,578,681
21	0.359		39,021	14,006
22	0.342		39,021	13,339
23	0.326		39,021	12,704
24	0.310		39,021	12,099
25	0.295		39,021	11,523
26	0.281		39,021	10,974
27	0.268		39,021	10,452
28	0.255		39,021	9,954
29	0.243		39,021	9,480
30	0.231		17,455,199	4,038,739
31	0.220		39,021	8,599
32	0.210		39,021	8,189
33	0.200		39,021	7,799
34	0.190		39,021	7,428
35	0.181		39,021	7,074
36	0.173		39,021	6,737
37	0.164		39,021	6,416
38	0.157		39,021	6,111
39	0.149		39,021	5,820
40	0.142		17,455,199	2,479,436
41	0.135		39,021	5,279
42	0.129		39,021	5,027
43	0.123		39,021	4,788
44	0.117		39,021	4,560
45	0.111		39,021	4,343
46	0.106		39,021	4,136
47	0.101		39,021	3,939
48	0.096		39,021	3,752
49	0.092		39,021	3,573
50	0.087			0
			Total Present Value of Costs	**56,303,933**
			Total Present Value of Benefits	**22,620,349**
			Total PVb plus intangibles	**45,240,699**
			Benefit Cost Ratio	**0.804**
			Net Present Value	**-11,063,234**

Appendix B Scenario C, No Flooding Threshold and 4 metres per year erosion

Step 1: Current Climate Annual Average Flood Damages

Table B-24: AADs associated with flooding under current climate- Scenario C

1	Current Climate Annual Average Flood Damages (Euros)				
	Scenarion A: No Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		799,418		
		0.004		743,700	2,975
200	0.005		687,982		
		0.005		670,224	3,351
100	0.01		652,465		
		0.01		634,168	6,342
50	0.02		615,871		
		0.03		583,284	17,499
20	0.05		550,697		
		0.05		490,313	24,516
10	0.1		429,928		
		0.1		384,756	38,476
5	0.2		339,585		
		0.3		322,507	96,752
2	0.5		305,429		
			Annual Average Damage		189,910

Step 2: Current Climate Annual Average Flood Benefits with Scheme

Table B-25: AADs associated with flooding with scheme in place under current climate - Scenario C

2	Current Climate Annual Average Flood Benefits (Euros)				
	No Property Thresholds -With 50 years Flood Alleviation				
Return Period (years)	Return Period Probability	Potential Damage (Euros)	Area under total Curve Total Damage	Residual Damage after scheme	Area under curve damage remaining
2	0.5	305,429			
5	0.2	339,585	96,752	-	
10	0.1	429,928	38,476	-	
20	0.05	550,697	24,516	-	
50	0.02	615,871	17,499	-	
100	0.01	652,465	6,342	-	
200	0.005	687,982	3,351	-	
1000	0.001	799,418	2,975		
			189,910		-
			Average Annual Benefits		189,910

Step 3: MRFS Annual Average Flood Damages

Table B-26: AADs associated with flooding under MRFS- Scenario C

3	Mid Range Future Annual Average Flood Damages (Euros)				
	Scenario A: No Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		10,702,226		
		0.004		8,919,392	35,678
200	0.005		7,136,558		
		0.005		6,684,822	33,424
100	0.01		6,233,085		
		0.01		5,837,959	58,380
50	0.02		5,442,833		
		0.03		4,841,234	145,237
20	0.05		4,239,635		
		0.05		3,816,017	190,801
10	0.1		3,392,398		
		0.1		2,988,490	298,849
5	0.2		2,584,583		
		0.3		2,097,637	629,291
2	0.5		1,610,691		
			Annual Average Damage		1,391,659

Step 4: MRFS Annual Average Flood Benefits with scheme

Table B-27: AADs associated with flooding with scheme in place under current climate - Scenario C

4	Mid Range Future Annual Average Flood Benefits (Euros)				
	No Property Thresholds -With 50 years Flood Alleviation				
Return Period	Probability	Potential Damage	Area under total Curve Total Damage	Damage after scheme	Area under curve damage remaining
2	0.5	1,610,691			
5	0.2	2,584,583	629,291	-	
10	0.1	3,392,398	298,849	-	
20	0.05	4,239,635	190,801	-	
50	0.02	5,442,833	145,237	-	
100	0.01	6,233,085	58,380	-	
200	0.005	7,136,558	33,424	-	
1000	0.001	10,702,226	35,678	10,702,226	35,678
			1,391,659		35,678
			Average Annual Benefits		1,355,982

Step 5: Interpolation of Flood Damages

Table B-28: PV of flooding benefits merging Current Climate with MRFS – Scenario C

5	Damages and benefits - Annualised data						
Year	Discount Rate	Curr Loss of AAD due to eroded properties	PVb Current (Current Climate)	MRFS Loss of AAD due to eroded properties	PvB MRFS Incremental Increase	Adjusted PvB	Present Value of Benefits (Linear Progression)
0	1.000	-	189,910	-	189,910	189,910	189,910
1	0.962		189,910	785	213,231	212,446	204,275
2	0.925		189,910	1,570	236,552	234,982	217,254
3	0.889		189,910	2,355	259,874	257,518	228,933
4	0.855		189,910	13,378	283,195	269,817	230,641
5	0.822		189,910	17,259	306,517	289,258	237,749
6	0.790		189,910	20,858	329,838	308,980	244,191
7	0.760		189,910	24,335	353,160	328,825	249,880
8	0.731		189,910	27,811	376,481	348,670	254,770
9	0.703		189,910	34,511	399,803	365,292	256,649
10	0.676		189,910	38,443	423,124	384,681	259,877
11	0.650		189,910	42,287	446,445	404,158	262,534
12	0.625		189,910	46,202	469,767	423,565	264,557
13	0.601		189,910	50,092	493,088	442,996	266,052
14	0.577		189,910	54,530	516,410	461,880	266,724
15	0.555		189,910	58,425	539,731	481,306	267,252
16	0.534		189,910	62,320	563,053	500,733	267,345
17	0.513		189,910	84,345	586,374	502,030	257,729
18	0.494		189,910	89,306	609,696	520,390	256,879
19	0.475		189,910	94,747	633,017	538,270	255,486
20	0.456		189,910	102,071	656,338	554,268	252,960
21	0.439		189,910	118,531	679,660	561,128	246,242
22	0.422		189,910	124,176	702,981	578,806	244,230
23	0.406		189,910	153,211	726,303	573,092	232,518
24	0.390		189,910	166,073	749,624	583,551	227,656
25	0.375		189,910	186,869	772,946	586,076	219,847
26	0.361		189,910	199,803	796,267	596,464	215,138
27	0.347		189,910	209,058	819,588	610,531	211,742
28	0.333		189,910	218,367	842,910	624,543	208,271
29	0.321		189,910	261,351	866,231	604,880	193,956
30	0.308		189,910	303,422	889,553	586,131	180,715
31	0.298		189,910	324,645	912,874	588,229	175,229
32	0.288		189,910	359,613	936,196	576,583	165,951
33	0.278		189,910	384,555	959,517	574,962	159,889
34	0.269		189,910	427,830	982,839	555,008	149,121
35	0.260		189,910	476,492	1,006,160	529,668	137,500
36	0.251		189,910	490,106	1,029,481	539,375	135,285
37	0.242		189,910	541,873	1,052,803	510,930	123,817
38	0.234		189,910	586,559	1,076,124	489,565	114,627
39	0.226		189,910	615,367	1,099,446	484,079	109,510
40	0.219		189,910	631,260	1,122,767	491,508	107,430
41	0.211		189,910	648,083	1,146,089	498,006	105,170
42	0.204		189,910	673,833	1,169,410	495,577	101,118
43	0.197		189,910	725,924	1,192,732	466,808	92,027
44	0.190		189,910	748,976	1,216,053	467,077	88,966
45	0.184		189,910	822,305	1,239,374	417,069	76,754
46	0.178		189,910	840,578	1,262,696	422,117	75,056
47	0.172		189,910	858,852	1,286,017	427,165	73,385
48	0.166		189,910	877,125	1,309,339	432,213	71,742
49	0.160		189,910	943,877	1,332,660	388,783	62,351
50	0.155		189,910	963,140	1,355,982	392,842	60,871
						PVb Floodir	**9,557,760**
						PVb Erosior	**52,204,586**
						Total PVb	**61,762,346**

Table B-29: Summary of flooded properties for current and MRFS climate scenarios based on an erosion rate of 4 m per year

Flooded properties	Number	# MRFS climate
1000 year	9	112
200 year	8	77
100 year	8	68
50 year	8	62
20 year	8	49
10 year	6	42
5 year	5	36
2 year	5	30

Step 6: Benefits with the 4 m/yr erosion scenario

Table B-30: PV of benefits associated with Scenario C

	Euros
PVb Flooding	9,557,760
PVb Property Erosion Loss	52,204,586
Total PVb	61,762,346

Table B-31: Successive properties lost to erosion up to year 50 based on an erosion rate of 4 m per year

Properties lost by erosion	Number
By Year 10	30
By year 20	82
By Year 30	141
By Year 40	200
By Year 50	233

Step 7: Sensitivity Analyses of Discount Rate

See Section 3, Step 7.

Step 8: Present Value of Benefits vs Present Value of Costs

See overleaf.

Table B-32: PVc vs PVb and resultant BCR for discount Scenario C (left) and C3 (right)

C BASE 4m/year erosion, no property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	4%	31 to 50 yrs	3.5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.962		39,021	37,520
2	0.925		39,021	36,077
3	0.889		39,021	34,689
4	0.855		39,021	33,355
5	0.822		39,021	32,072
6	0.790		39,021	30,839
7	0.760		39,021	29,653
8	0.731		39,021	28,512
9	0.703		39,021	27,415
10	0.676		17,455,199	11,792,107
11	0.650		39,021	25,347
12	0.625		39,021	24,372
13	0.601		39,021	23,435
14	0.577		39,021	22,533
15	0.555		39,021	21,667
16	0.534		39,021	20,833
17	0.513		39,021	20,032
18	0.494		39,021	19,262
19	0.475		39,021	18,521
20	0.456		17,455,199	7,966,325
21	0.439		39,021	17,124
22	0.422		39,021	16,465
23	0.406		39,021	15,832
24	0.390		39,021	15,223
25	0.375		39,021	14,637
26	0.361		39,021	14,074
27	0.347		39,021	13,533
28	0.333		39,021	13,013
29	0.321		39,021	12,512
30	0.235		17,455,199	4,097,272
31	0.224		39,021	8,723
32	0.213		39,021	8,308
33	0.203		39,021	7,912
34	0.193		39,021	7,535
35	0.184		39,021	7,177
36	0.175		39,021	6,835
37	0.167		39,021	6,509
38	0.159		39,021	6,199
39	0.151		39,021	5,904
40	0.144		17,455,199	2,515,369
41	0.137		39,021	5,355
42	0.131		39,021	5,100
43	0.124		39,021	4,857
44	0.119		39,021	4,626
45	0.113		39,021	4,406
46	0.108		39,021	4,196
47	0.102		39,021	3,996
48	0.098		39,021	3,806
49	0.093		39,021	3,625
50	0.155			0
			Total Present Value of Costs	58,930,067
			Total Present Value of Benefits	61,762,346
			Total PVb plus intangibles	123,524,693
			Benefit Cost Ratio	2.096
			Net Present Value	64,594,626

C3 4m/year erosion, no property flooding Threshold				
	Test Discount Rates			
0 to 30yrs	3%	31 to 50 yrs	3%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.971		39,021	37,884
2	0.943		39,021	36,781
3	0.915		39,021	35,709
4	0.888		39,021	34,669
5	0.863		39,021	33,660
6	0.837		39,021	32,679
7	0.813		39,021	31,727
8	0.789		39,021	30,803
9	0.766		39,021	29,906
10	0.744		17,455,199	12,988,307
11	0.722		39,021	28,189
12	0.701		39,021	27,368
13	0.681		39,021	26,571
14	0.661		39,021	25,797
15	0.642		39,021	25,046
16	0.623		39,021	24,316
17	0.605		39,021	23,608
18	0.587		39,021	22,921
19	0.570		39,021	22,253
20	0.554		17,455,199	9,664,520
21	0.538		39,021	20,976
22	0.522		39,021	20,365
23	0.507		39,021	19,771
24	0.492		39,021	19,196
25	0.478		39,021	18,637
26	0.464		39,021	18,094
27	0.450		39,021	17,567
28	0.437		39,021	17,055
29	0.424		39,021	16,558
30	0.412		17,455,199	7,191,311
31	0.400		39,021	15,608
32	0.388		39,021	15,153
33	0.377		39,021	14,712
34	0.366		39,021	14,283
35	0.355		39,021	13,867
36	0.345		39,021	13,463
37	0.335		39,021	13,071
38	0.325		39,021	12,691
39	0.316		39,021	12,321
40	0.307		17,455,199	5,351,011
41	0.298		39,021	11,614
42	0.289		39,021	11,275
43	0.281		39,021	10,947
44	0.272		39,021	10,628
45	0.264		39,021	10,319
46	0.257		39,021	10,018
47	0.249		39,021	9,726
48	0.242		39,021	9,443
49	0.235		39,021	9,168
50	0.228			0
			Total Present Value of Costs	67,946,940
			Total Present Value of Benefits	74,382,906
			Total PVb plus intangibles	148,765,811
			Benefit Cost Ratio	2.189
			Net Present Value	80,818,872

Table B-33: PVc vs PVb and resultant BCR for discount Scenario C5

C5 4m/year erosion, no property flooding Threshold				
Test Discount Rates				
0 to 30yrs	5%	31 to 50 yrs	5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.952		39,021	37,163
2	0.907		39,021	35,393
3	0.864		39,021	33,708
4	0.823		39,021	32,102
5	0.784		39,021	30,574
6	0.746		39,021	29,118
7	0.711		39,021	27,731
8	0.677		39,021	26,411
9	0.645		39,021	25,153
10	0.614		17,455,199	10,715,978
11	0.585		39,021	22,815
12	0.557		39,021	21,728
13	0.530		39,021	20,694
14	0.505		39,021	19,708
15	0.481		39,021	18,770
16	0.458		39,021	17,876
17	0.436		39,021	17,025
18	0.416		39,021	16,214
19	0.396		39,021	15,442
20	0.377		17,455,199	6,578,681
21	0.359		39,021	14,006
22	0.342		39,021	13,339
23	0.326		39,021	12,704
24	0.310		39,021	12,099
25	0.295		39,021	11,523
26	0.281		39,021	10,974
27	0.268		39,021	10,452
28	0.255		39,021	9,954
29	0.243		39,021	9,480
30	0.231		17,455,199	4,038,739
31	0.220		39,021	8,599
32	0.210		39,021	8,189
33	0.200		39,021	7,799
34	0.190		39,021	7,428
35	0.181		39,021	7,074
36	0.173		39,021	6,737
37	0.164		39,021	6,416
38	0.157		39,021	6,111
39	0.149		39,021	5,820
40	0.142		17,455,199	2,479,436
41	0.135		39,021	5,279
42	0.129		39,021	5,027
43	0.123		39,021	4,788
44	0.117		39,021	4,560
45	0.111		39,021	4,343
46	0.106		39,021	4,136
47	0.101		39,021	3,939
48	0.096		39,021	3,752
49	0.092		39,021	3,573
50	0.087			0
			Total Present Value of Costs	**56,303,933**
			Total Present Value of Benefits	**51,286,781**
			Total PVb plus intangibles	**102,573,562**
			Benefit Cost Ratio	**1.822**
			Net Present Value	**46,269,628**

Appendix C Scenario D, 200mm Flooding Threshold and 4 metres per year erosion

Step 1: Current Climate Annual Average Flood Damages

Table C-34: AADs associated with flooding under current climate- Scenario D

1	Current Climate Annual Average Flood Damages (Euros)				
	Scenarion A: 200mm Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		799,418		
		0.004		743,700	2,975
200	0.005		687,982		
		0.005		670,224	3,351
100	0.01		652,465		
		0.01		634,168	6,342
50	0.02		615,871		
		0.03		583,284	17,499
20	0.05		550,697		
		0.05		490,313	24,516
10	0.1		429,928		
		0.1		384,756	38,476
5	0.2		339,585		
		0.3		322,507	96,752
2	0.5		305,429		
			Annual Average Damage		189,910

Step 2: Current Climate Annual Average Flood Benefits with Scheme

Table C-35: AADs associated with flooding with scheme in place under current climate - Scenario D

2	Current Climate Annual Average Flood Benefits (Euros)				
	200mm Property Thresholds -With 50 years Flood Alleviation				
Return Period (years)	Return Period Probability	Potential Damage (Euros)	Area under total Curve Total Damage	Residual Damage after scheme	Area under curve damage remaining
2	0.5	305,429			
5	0.2	339,585	96,752	-	
10	0.1	429,928	38,476	-	
20	0.05	550,697	24,516	-	
50	0.02	615,871	17,499	-	
100	0.01	652,465	6,342	-	
200	0.005	687,982	3,351	-	
1000	0.001	799,418	2,975		
			189,910		-
			Average Annual Benefits		189,910

Step 3: MRFS Annual Average Flood Damages

Table C-36: AADs associated with flooding under MRFS- Scenario D

3	Mid Range Future Annual Average Flood Damages (Euros)				
	Scenario A: 200mm Property Thresholds -Without Flood Alleviation				
Return Period (years)	Return Period Probability	Difference in probability	Damage (Euros)	Damage in Interval	Annual Average Damage in Interval
1000	0.001		6,967,391		
		0.004		5,782,660	23,131
200	0.005		4,597,928		
		0.005		4,188,750	20,944
100	0.01		3,779,572		
		0.01		3,325,369	33,254
50	0.02		2,871,165		
		0.03		2,327,900	69,837
20	0.05		1,784,634		
		0.05		1,472,803	73,640
10	0.1		1,160,971		
		0.1		1,026,590	102,659
5	0.2		892,208		
		0.3		772,183	231,655
2	0.5		652,159		
			Annual Average Damage		555,119

Step 4: MRFS Annual Average Flood Benefits with scheme

Table C-37: AADs associated with flooding with scheme in place under current climate - Scenario D

4	Mid Range Future Annual Average Flood Benefits (Euros)				
	200mm Property Thresholds -With 50 years Flood Alleviation				
Return Period	Probability	Potential Damage	Area under total Curve Total Damage	Damage after scheme	Area under curve damage remaining
2	0.5	652,159			
5	0.2	892,208	231,655	-	
10	0.1	1,160,971	102,659	-	
20	0.05	1,784,634	73,640	-	
50	0.02	2,871,165	69,837	-	
100	0.01	3,779,572	33,254	-	
200	0.005	4,597,928	20,944	-	
1000	0.001	6,967,391	23,131	6,967,391	23,131
			555,119		23,131
			Average Annual Benefits		531,989

Step 5: Interpolation of Flood Damages

Table C-38: PV of flooding benefits merging Current Climate with MRFS – Scenario A1

5	Damages and benefits - Annualised data						
Year	Discount Rate	Curr Loss of AAD due to eroded properties	PVb Current (Current Climate)	MRFS Loss of AAD due to eroded properties	PvB MRFS Incremental Increase	Adjusted PvB	Present Value of Benefits (Linear Progression)
0	1.000	-	189,910	-	189,910	189,910	189,910
1	0.962		189,910	147	196,751	196,604	189,043
2	0.925		189,910	294	203,593	203,299	187,962
3	0.889		189,910	440	210,434	209,994	186,684
4	0.855		189,910	3,893	217,276	213,383	182,400
5	0.822		189,910	4,919	224,117	219,199	180,165
6	0.790		189,910	5,918	230,959	225,041	177,854
7	0.760		189,910	6,904	237,801	230,897	175,463
8	0.731		189,910	7,890	244,642	236,752	172,992
9	0.703		189,910	9,280	251,484	242,204	170,169
10	0.676		189,910	10,322	258,325	248,004	167,542
11	0.650		189,910	11,354	265,167	253,813	164,872
12	0.625		189,910	12,394	272,009	259,614	162,154
13	0.601		189,910	13,427	278,850	265,423	159,406
14	0.577		189,910	14,520	285,692	271,171	156,595
15	0.555		189,910	15,558	292,533	276,976	153,795
16	0.534		189,910	16,595	299,375	282,780	150,979
17	0.513		189,910	19,729	306,216	286,487	147,075
18	0.494		189,910	20,890	313,058	292,168	144,222
19	0.475		189,910	22,099	319,900	297,800	141,349
20	0.456		189,910	23,503	326,741	303,239	138,394
21	0.439		189,910	26,184	333,583	307,399	134,897
22	0.422		189,910	27,431	340,424	312,994	132,069
23	0.406		189,910	31,808	347,266	315,458	127,990
24	0.390		189,910	33,804	354,107	320,303	124,957
25	0.375		189,910	43,643	360,949	317,306	119,027
26	0.361		189,910	46,539	367,791	321,252	115,872
27	0.347		189,910	48,448	374,632	326,184	113,126
28	0.333		189,910	50,457	381,474	331,017	110,387
29	0.321		189,910	78,537	388,315	309,779	99,331
30	0.308		189,910	85,327	395,157	309,830	95,526
31	0.298		189,910	95,770	401,999	306,229	91,223
32	0.288		189,910	101,998	408,840	306,843	88,315
33	0.278		189,910	110,992	415,682	304,690	84,730
34	0.269		189,910	143,624	422,523	278,899	74,935
35	0.260		189,910	158,111	429,365	271,254	70,417
36	0.251		189,910	162,628	436,206	273,578	68,618
37	0.242		189,910	172,048	443,048	271,000	65,673
38	0.234		189,910	180,533	449,890	269,357	63,067
39	0.226		189,910	186,838	456,731	269,893	61,056
40	0.219		189,910	191,629	463,573	271,944	59,440
41	0.211		189,910	196,472	470,414	273,942	57,852
42	0.204		189,910	202,302	477,256	274,954	56,102
43	0.197		189,910	241,047	484,097	243,050	47,915
44	0.190		189,910	247,393	490,939	243,546	46,389
45	0.184		189,910	273,738	497,781	224,043	41,231
46	0.178		189,910	279,821	504,622	224,801	39,972
47	0.172		189,910	285,904	511,464	225,560	38,750
48	0.166		189,910	291,987	518,305	226,318	37,566
49	0.160		189,910	306,864	525,147	218,283	35,007
50	0.155		189,910	313,127	531,989	218,862	33,913
						PVb Flooding	**5,834,376**
						PVb Erosion (2m	**52,204,586**
						Total PVb	**58,038,962**

Table C-39: Summary of flooded properties for current and MRFS climate scenarios based on an erosion rate of 4 m per year

Flooded properties	Number	# MRFS climate
1000 year	8	81
200 year	8	55
100 year	6	50
50 year	6	43
20 year	5	33
10 year	4	21
5 year	4	18
2 year	3	13

Step 6: Benefits with the 4 m/yr erosion scenario

Table C-40: PV of benefits associated with Scenario A1

	Euros
PVb Flooding	5,834,376
PVb Property Erosion Loss	52,204,586
Total PVb	58,038,962

Table C-41: Successive properties lost to erosion up to year 50 based on an erosion rate of 4 m per year

Properties lost by erosion	Number
By Year 10	30
By Year 20	82
By Year 30	141
By Year 40	200
By Year 50	233

Step 7: Sensitivity Analyses of Discount Rate

See Section 3, Step 7.

Step 8: Present Value of Benefits vs Present Value of Costs

See overleaf.

Table C-42: PVc vs PVb and resultant BCR for discount Scenario D (left) and D3 (right)

D base 4m/year erosion, 200mm property flooding Threshold				
Test Discount Rates				
0 to 30yrs	4%	31 to 50 yrs	3.5%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.962		39,021	37,520
2	0.925		39,021	36,077
3	0.889		39,021	34,689
4	0.855		39,021	33,355
5	0.822		39,021	32,072
6	0.790		39,021	30,839
7	0.760		39,021	29,653
8	0.731		39,021	28,512
9	0.703		39,021	27,415
10	0.676		17,455,199	11,792,107
11	0.650		39,021	25,347
12	0.625		39,021	24,372
13	0.601		39,021	23,435
14	0.577		39,021	22,533
15	0.555		39,021	21,667
16	0.534		39,021	20,833
17	0.513		39,021	20,032
18	0.494		39,021	19,262
19	0.475		39,021	18,521
20	0.456		17,455,199	7,966,325
21	0.439		39,021	17,124
22	0.422		39,021	16,465
23	0.406		39,021	15,832
24	0.390		39,021	15,223
25	0.375		39,021	14,637
26	0.361		39,021	14,074
27	0.347		39,021	13,533
28	0.333		39,021	13,013
29	0.321		39,021	12,512
30	0.235		17,455,199	4,097,272
31	0.224		39,021	8,723
32	0.213		39,021	8,308
33	0.203		39,021	7,912
34	0.193		39,021	7,535
35	0.184		39,021	7,177
36	0.175		39,021	6,835
37	0.167		39,021	6,509
38	0.159		39,021	6,199
39	0.151		39,021	5,904
40	0.144		17,455,199	2,515,369
41	0.137		39,021	5,354
42	0.131		39,021	5,100
43	0.124		39,021	4,857
44	0.119		39,021	4,626
45	0.113		39,021	4,406
46	0.108		39,021	4,196
47	0.102		39,021	3,996
48	0.098		39,021	3,806
49	0.093		39,021	3,625
50	0.155			0
			Total Present Value of Costs	58,930,065
			Total Present Value of Benefits	58,038,962
			Total PVb plus intangibles	116,077,924
			Benefit Cost Ratio	1.970
			Net Present Value	57,147,859

D3 4m/year erosion, 200mm property flooding Threshold				
Test Discount Rates				
0 to 30yrs	3%`	31 to 50 yrs	3.0%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.971		39,021	37,884
2	0.943		39,021	36,781
3	0.915		39,021	35,709
4	0.888		39,021	34,669
5	0.863		39,021	33,660
6	0.837		39,021	32,679
7	0.813		39,021	31,727
8	0.789		39,021	30,803
9	0.766		39,021	29,906
10	0.744		17,455,199	12,988,307
11	0.722		39,021	28,189
12	0.701		39,021	27,368
13	0.681		39,021	26,571
14	0.661		39,021	25,797
15	0.642		39,021	25,046
16	0.623		39,021	24,316
17	0.605		39,021	23,608
18	0.587		39,021	22,921
19	0.570		39,021	22,253
20	0.554		17,455,199	9,664,520
21	0.538		39,021	20,976
22	0.522		39,021	20,365
23	0.507		39,021	19,771
24	0.492		39,021	19,196
25	0.478		39,021	18,637
26	0.464		39,021	18,094
27	0.450		39,021	17,567
28	0.437		39,021	17,055
29	0.424		39,021	16,558
30	0.412		17,455,199	7,191,311
31	0.400		39,021	15,608
32	0.388		39,021	15,153
33	0.377		39,021	14,712
34	0.366		39,021	14,283
35	0.355		39,021	13,867
36	0.345		39,021	13,463
37	0.335		39,021	13,071
38	0.325		39,021	12,691
39	0.316		39,021	12,321
40	0.307		17,455,199	5,351,011
41	0.298		39,021	11,614
42	0.289		39,021	11,275
43	0.281		39,021	10,947
44	0.272		39,021	10,628
45	0.264		39,021	10,319
46	0.257		39,021	10,018
47	0.249		39,021	9,726
48	0.242		39,021	9,443
49	0.235		39,021	9,168
50	0.228			0
			Total Present Value of Costs	67,946,940
			Total Present Value of Benefits	69,758,011
			Total PVb plus intangibles	139,516,023
			Benefit Cost Ratio	2.053
			Net Present Value	71,569,083

Table C-43: PVc vs PVb and resultant BCR for discount Scenario D5

D5 4m/year erosion, 200mm property flooding Threshold				
Test Discount Rates				
0 to 30yrs	5%	31 to 50 yrs	5.0%	
Year	Discount Rate	Capital Costs	Maintenance Costs	Present Value of Costs
0	1.000	31,835,376		31,835,376
1	0.952		39,021	37,163
2	0.907		39,021	35,393
3	0.864		39,021	33,708
4	0.823		39,021	32,102
5	0.784		39,021	30,574
6	0.746		39,021	29,118
7	0.711		39,021	27,731
8	0.677		39,021	26,411
9	0.645		39,021	25,153
10	0.614		17,455,199	10,715,978
11	0.585		39,021	22,815
12	0.557		39,021	21,728
13	0.530		39,021	20,694
14	0.505		39,021	19,708
15	0.481		39,021	18,770
16	0.458		39,021	17,876
17	0.436		39,021	17,025
18	0.416		39,021	16,214
19	0.396		39,021	15,442
20	0.377		17,455,199	6,578,681
21	0.359		39,021	14,006
22	0.342		39,021	13,339
23	0.326		39,021	12,704
24	0.310		39,021	12,099
25	0.295		39,021	11,523
26	0.281		39,021	10,974
27	0.268		39,021	10,452
28	0.255		39,021	9,954
29	0.243		39,021	9,480
30	0.231		17,455,199	4,038,739
31	0.220		39,021	8,599
32	0.210		39,021	8,189
33	0.200		39,021	7,799
34	0.190		39,021	7,428
35	0.181		39,021	7,074
36	0.173		39,021	6,737
37	0.164		39,021	6,416
38	0.157		39,021	6,111
39	0.149		39,021	5,820
40	0.142		17,455,199	2,478,638
41	0.135		39,021	5,279
42	0.129		39,021	5,027
43	0.123		39,021	4,788
44	0.117		39,021	4,560
45	0.111		39,021	4,343
46	0.106		39,021	4,136
47	0.101		39,021	3,939
48	0.096		39,021	3,752
49	0.092		39,021	3,573
50	0.087			0
			Total Present Value of Costs	**56,303,136**
			Total Present Value of Benefits	**48,311,219**
			Total PVb plus intangibles	**96,622,438**
			Benefit Cost Ratio	**1.716**
			Net Present Value	**40,319,302**

Appendix D Experience of John Chatterton

John Chatterton is former consultant and lecturer in project appraisal and business systems for the water, river management and utilities industry, with a career spanning over 35 years working in UK, Asia, the United States, the Caribbean, Russia and Europe.

Dr. Chatterton was also the principal associate with the internationally renowned Flood Hazard Research Centre of Middlesex University, London. John is the author of innovative technical publications and consultancy reports in flood risk management economics, including *"The Benefits of Flood Alleviation*" with Professor Edmund Penning-Rowsell OBE. This book and its subsequent companion publications produced at FHRC are the recommended texts/manuals for the cost-benefit appraisal of all UK and Ireland coastal and fluvial catchment and shoreline flood management plans, flood alleviation strategies and schemes. John was technical adviser and co-author of the 2005 and 2010 updates of all FHRC Manuals and Handbooks. The application of cost benefit economics has taken John on extended flood risk management projects to Russia (St Petersburg Flood barrier), Turkey (Black Sea communities), Poland (River Odra). Slovakia (River Danube at Bratislava), Romania (Prut/Barlad catchment) and Algeria (Algers).

John also specialised in asset management in both the water and river sectors and has coordinated projects in the Ukraine and Trinidad and Tobago, and in UK as a framework contractor to the Environment Agency. and adviser to the Northern Irish Rivers Agency. John has also worked with Severn Trent Water International on organisational reviews and privatization initiatives for water utilities in Russia, Ukraine, Georgia, Moldova, Turkey, Bangladesh and India.