NATIONAL 'CFRAM' PROGRAMME

Technical Methodology Note - Cost-Benefit Analysis (CBA)

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1.0	**PURPOSE**
	The purpose of National 'CFRAM' Programme Technical Methodology Note is to set out a common approach to the calculation of monetarised, economic flood damages and the economic benefits of flood risk management options, and for undertaking a cost-benefit analysis, with a view to ensuring that damages, benefits and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.
2.0	**SCOPE**
	This Note relates to the calculation of monetarised, economic flood damages and the potential economic benefits of options for flood risk management measures, for the purposes of: – The calculation of the economic (monetary) benefit-cost ratio for options for flood risk management measures to be used for option appraisal and economic flood risk mapping – Option appraisal against Objective 2.a (Minimise Economic Risk) under the Multi-Criteria Analysis (MCA) Note that there are minor variations in the benefit / damage values to be used for the two purposes above (see Section 4.5 herein). This Note does not address to: – The calculation of the costs of options for flood risk management measures, which is calculated with reference to the OPW Unit Cost Database – The application of the Multi-Criteria Analysis (MCA) to appraise flood risk management measures (except for Objective 2.a), for which guidance is produced in The Technical Methodology Note on the MCA. A glossary of abbreviations / acronyms used for this GN is provided in Appendix A. An explanatory table is provided in Appendix B, that might be useful for clarity.

3.0	CALCULATION OF ECONOMIC FLOOD DAMAGES
3.1	**General Requirements** The requirements for the calculation of economic risk, and hence economic flood damages are as set out in Section 8 and Appendix I of the Generic CFRAM Project Brief. ***General Methodology*** The calculation of flood damages should be based on the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC 2010, subject to caveats, amendments and clarifications set out herein ***Price Conversions*** Prices (damage costs) in the data provided by FHRC 2010 should be converted to euro rates applicable to Ireland in 2013 by: - Applying a 'PPP' multiplication factor of 1.279. This is derived from the relative OECD Purchasing Price Parity values for the UK and for Ireland for 2010. The 'PPP' factor is net of currency conversion (i.e., already includes for exchange rates as well as price differences, and so no currency conversion rate should be applied in addition to this factor) - Applying an inflation multiplication factor of 1.051. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013 ***Flood Duration*** The damages should be calculated assuming long duration (>12 hours) flooding for residential properties, except where shorter duration flooding (including the time required for the draining away of flood waters) would clearly be expected, e.g., in small, flashy catchments, where the duration of <12 hours should be applied instead. For non-residential properties, shorter duration flooding (<12 hours) should be assumed, as depth-damage data for longer duration flooding of non-residential properties is not provided in FHRC 2010. ***Coastal Flooding*** The addition of 10% on building fabric damages should be used when assessing flooding from coastal / tidal sources.
3.2	**Scope of Assessment** The calculation of flood damages should be undertaken for: - AFAs and areas along MPWs - The current scenario and MRFS based on each of the range of flood event probabilities as set out in Section 6.5.1 of the Generic CFRAM Project Brief - The HEFS in an indicative manner, making use of calculated damages for the 10%, 1% (0.5% for coastal flooding) and 0.1% damages for the HEFS, and using these values to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.

3.3	**Residential Property Damages** ***Residential Property Classifications*** For the purposes of determining the appropriate residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (detached, semi-detached, terraced, bungalow, etc.) but not: - Property age - Social class (and without inclusion of the Distributional Impact Factor) - Property size The use of properties marked as 'unknown' in the GeoDirectory can be confirmed through the site visits and/or by remote data such as Google Street Map ***Property Floor Levels and Flood Depths*** As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, residential property floor levels (which is the base-line or zero-depth against for the calculation of flood damages) may be determined, subject to confirmation by the CFRAM Consultant through spot-checks, on the basis that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height of the doorstep / floor level adopted for each AFA should be based on observation / measurement for each AFA. Flood damages should be assumed to begin at flood depths of –0.3m relative to floor levels. This only applies however to properties whose foot-print lies within the flooded area, and does not need to be calculated for properties that are situated outside of the flood extents for the given event. For properties with basements, the flood damages for the property assuming a depth of 2.4m (typical ceiling height) should be applied once the flood depth exceeds the threshold level for the basement (i.e., the lowest level that allows significant flood waters to enter). This damage should be in addition to the normal depth-damage calculation for the ground floor of the property.
3.4	**Non-Residential Property Damages** ***Non-Residential Property Classifications*** The Indicative Susceptibility depth-damage curve / data should be used, unless there is a clear and specific reason to use the High or Low Susceptibility Band data for a given property. For the purposes of determining the appropriate non-residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (i.e., sub-classes of the 'Bulk Code Class', and with a three-digit 'MCM Code', as referred to in FHRC 2005 & 2010), and, - Property area

	Property Floor Levels and Flood Depths As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, non-residential property floor levels may generally be determined, subject to confirmation by the Consultant through spot-checks and the exceptions as set out below, that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height adopted for each AFA should be based on observation / measurement for each AFA. Surveys of the threshold levels for flooding of major commercial properties (those with estimated potential damages greater or equal to €500,000 for an event of annual exceedence probability of 0.1% in the AFA), and also for entry points to significant basements or underground car-parks, are however required, and these levels where captured should be used. Flood damages should be assumed to begin at flood depths of 0m. For mixed-use properties, i.e., where the property includes both residential and (non-residential) commercial use, it could be assumed (unless otherwise verified through site visit / remote data) that the ground floor will typically be in non-residential (commercial) use, and so the non-residential approach should be applied, i.e., assume flood damages begin at 0m rather than -0.3m. For converted properties that are now non-residential, the non-residential approach should be applied The 'with basements' or 'without basements' depth-damage data for non-residential properties should be used as appropriate. Where the existence or otherwise of a basement is unknown for a given property, then the 'without basement' depth-damage data should be used. In line with good practice, a 'reality-check' should be undertaken for any property that contributes more than 1% of the total PV damages for an AFA.
3.5	**Other Damage Costs** ***Principal Direct Damage (PDD) Costs*** The PDD Costs are calculated as the sum of the residential and non-residential property damages. The PDD Cost is used as the baseline for the calculation of other damage costs, as set out below. ***Infrastructural Utility Assets*** Economic damages to infrastructural utility assets (e.g., electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) should be calculated as 20% of total PDD Costs for the AFA or SSA. *(Note: 20% value has been derived from the analysis of damages of past floods in the UK).* Infrastructural Utility Damage Costs should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA. ***Emergency Services*** Costs to emergency services (which include evacuation costs) should be included in the economic damages, and should be calculated as 8.1% of the total PDD Costs for the AFA or SSA.

(Note: 8.1% value derived as average of the measured emergency services costs for the 2000 and 2007 floods in the UK).

Traffic Disruption

Costs of traffic disruption may typically be excluded from the calculation of the economic damages, as it will typically not be significant within the overall damages. This would be, for example, where the flooding would be of minor roads or local urban streets and where alternative local routes are available and/or traffic volumes will not be high. Traffic disruption costs may however be included where there are major (high volume) roads affected and / or where deviation routes are of significant distance.

The inclusion or otherwise of traffic disruption costs is at the discretion of the CFRAM Consultants, subject to advice from the Steering / Progress Group.

In the event that traffic disruption costs are calculated, then such damages / costs should be included for the economic CBA, but should not be included in the appraisal against Objective 2.a under the MCA.

Risk to Life

While clearly of significant importance in the overall appraisal under the MCA, the potential damage costs of loss of life in a flood event are not to be included in the assessment of economic damages.

(Note: This is excluded because, while loss of life can occur in flood events, in Ireland loss of life in a community that might be classified as an APSR (AFA) is very rare. As such, it would not materially change the economic analysis.)

Where risk to life is of potentially significant concern (e.g., where there is a prevalence of basements and / or by observation of the flood hazard (risk to life) mapping and the location of residential / high vulnerability properties), this should be noted in the description of flood risk for the AFA, and can be taken into account in option selection and justification.

Other Excluded Damage Costs

Damage costs can arise in relation to various other types of damage, impacts or costs arising in the event of a flood. However, these are either not economic losses (i.e., to the overall national economy), are provided for under another included cost, and / or are typically relatively small as a percentage of the overall damage and hence do not need to be considered in the economic appraisal at this strategic level of assessment.

Such excluded costs would include:

- Damage to roads
- Damage to parked cars
- Environmental damage
- Personal evacuation costs
- Temporary accommodation

	- Extra heating costs - Losses to businesses - Recreational losses Many of the above costs are deemed to be included within the Intangible and Indirect Damages (see Item 3.6 below).
3.6	**Intangible and Indirect Damages** Flood events can cause significant stress, anxiety and ill health to potentially affected people, during and then after a flood. Individuals generally also incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc. While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion (Chatterton, pers. comm) has indicated that they could well be greater than the direct damages to residential properties. For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damage. Intangible damages may also be applied in the case of small, individually or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential. The inclusion of intangible damages for non-residential properties (if included) shall however be justified on a property-by-property basis, and may not be generally applied across an entire sector or sub-sector. While recognising that there will be some impact to those living above ground floor level (e.g., in apartment buildings), the intangible impact will, in line with the economic damages, be quite limited relative to those in properties that are flooded, and so these damages should not be included at the CFRAM level of analysis. Intangible and indirect damages should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA (as they are provided for under other MCA objectives).
3.7	**Calculation of Annual Average Damage** The Annual Average Damage (AAD) shall be calculated using linear interpolation between damage values for each of the eight defined design event probabilities, i.e., with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'. The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.

3.8	**Calculation of the Present Value of Damages (PVd)** The PVd should be calculated as the discounted sum of the annual average damages over the project horizon, where: - The discount rate to be applied is 4% - The project horizon is 50 years The discount rate is subject to sensitivity testing (see Section 5.1).
4.0	**CALCULATION OF ECONOMIC BENEFITS OF FLOOD RISK MANAGEMENT OPTIONS**
4.1	**General Requirements** The economic benefits of an option for a flood risk management measure, or of a proposed flood risk management measure, are calculated as the reduction in the economic damages the option or measure will provide. The benefits / damages should be calculated assuming protection to the defined / proposed Standard of Protection (SoP), i.e., not taking into account freeboard / factor of safety. ***Baseline Scenario*** The baseline scenario against which benefits of an option or measure should be compared is the current situation or 'continue with existing practice' in terms of arterial drainage maintenance, local authority maintenance regimes for urban channels, culvert inlets, etc. *(Note: This is different from the usual 'Do Nothing' baseline scenario against which benefits of further action, or maintaining the status quo, are measured. This is necessary due to the nature of current activities, and the uncertainty associated with damages that would arise should those activities cease).* ***Defence Options or Measures*** For options or measures involving direct flood defence of an area, such as a wall or embankment, the reduction in damages should be calculated as the damages avoided to up and including the standard of protection of the option or measure, with no benefit offered for events greater than standard of protection. *(Note: This approach will tend to under-estimate the benefits of an option or measure, as it ignores the residual benefits for greater-than-design events. However, these residual benefits would be offset to some degree by increased damages that could arise in the event of the failure of the defence, and the above approach simplifies that analysis required.)* ***Other Flood Hazard Reduction Options or Measures*** For options or measures that involve reducing flood flows or levels through the relevant area, such as flood water retention or increasing in-bank channel capacity, the reduction in damages will need to be calculated by running the model for the flood event probabilities for which flooding and damage will occur to determine the flood damages for those events, and hence the reduction in damages from the current scenario. The event of probability equal to the standard of protection, or for which no flooding or damages would arise, will also need to be run to demonstrate the effectiveness of the option or measure at the intended 'zero-damage' event probability.

4.2	**Present Value of Benefits (PVb)** The PVb of an option or measure is the reduction in the Present Value of damages (PVd) that would be achieved by implementing the option or measure (where the PVd is calculated as set out in Section 3.8 herein based on the discount rate and the project horizon), but also taking into account the capping of benefits as set out in Section 4.3 below.
4.3	**Property Value Capping** The costs of a measure or scheme (i.e., an option) with respect to a particular property should not exceed the total value of that property and, where relevant, the intangible damages that can be avoided through relocation; otherwise the State could end up investing more in protecting an asset than the value of that asset and associated intangible consequences, and a lower cost alternative measure (relocation) could be implemented instead. Capping values are hence applied to PVb of an option when undertaking an economic CBA. Capping should not be applied to the property damages for the appraisal against Objective 2.a under the MCA nor for the economic damage risk maps, as these should reflect the 'Do Nothing' or current situation. ***Residential Property Value Capping*** The capping value of the Principal Direct Damages (PDD) for a residential property is based on the value of that property. The value for a given property can be based on local or regional valuations of that type of property, i.e., a property-specific valuation is not required. Information on residential property prices is available from a number of publicly available sources (e.g., Residential Property Price Register, Property websites, etc.). The total capping value should however also take into account the PVd related to the intangible damages for a property, noting that these can be ongoing and not only the direct consequences of a given flood. The PVb capping value for intangible benefits of an option should be set equal to the capping value for the PDD for the property, representing the intangible damages avoided over the project horizon if the property (and it's residents) were to be relocated, but taking into account the capping of the PDD of the property. The Total Capping Value for the PVb for a residential property is therefore calculated as the sum of the capping value for the PDD for a property and the capping value of the intangible damages for that property. As the latter is equal to the former, this value is effectively double the capping value for the PDD of a property (i.e., double the property value). **Non-Residential Property Value Capping** The capping value for the PVb for a given non-residential property can be derived from regional valuations of that type of property, taking account of typical stock, or as ten (10) times the current rateable value of the property.

	Capping of Other Damages Capping should be applied to property damages and intangible damages only. Capping should not be applied to damages calculated as a percentage of the Principal Direct Damages (PDD), such as emergency services costs.
4.4	**Exclusions from Benefit Calculations** Potential increases in property value (including land value) arising from the implementation of a scheme may not be counted as scheme benefits.
4.5	**Reduction in Risk (Benefits) for Appraisal against MCA Objective 2.a** The economic benefits used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio should be as set out above. The economic benefits used for the appraisal of options or measures under the MCA against Objective 2.a (Minimise Economic Risk) are as set out above, but should not be capped (Section 4.3) and with certain exclusions as referred to above, including: - Benefits to infrastructural utilities (Section 3.5) - Benefits in reduction of disruption to traffic (Section 3.5) - Intangible and indirect benefits (Section 3.6) These exclusions are to avoid double-counting benefits within the MCA. Further guidance on scoring under the MCA against Objective 2.a is given in the Technical Methodology Note on the MCA.
5.0	**COST – BENEFIT ANALYSIS**
5.1	**General Methodology** The benefit-cost ratio (BCR) to be produced as the output of the cost-benefit analysis is calculated by dividing the PVb for an option or measure, capped as appropriate, by the whole life cost (PVc) of that option or measure. The Net Present Value of the benefits (NPVb) of the option should also be calculated by deducting the PVc from the capped PVb. Further guidance on deriving costs for options or measures is provided under the guidance on the use of Unit Cost Database. The whole life cost is determined from the sum of the costs over the project horizon, with future costs discounted by the set discount rate (see Section 3.8 herein). It should be noted that residual asset values of potential flood risk management measures (i.e., at the end of the project horizon) should be assumed to be zero. Measures are only likely to be recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.

	As set out in the Generic CFRAM Project Brief, sensitivity tests should be undertaken to determine the BCR using higher or lower discount rates, which should be 5% and 3% respectively.
6.0	**ECONOMIC RISK MAPPING**
	For the economic risk mapping, the AAD should be calculated in the same way as calculating the economic damages to be used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio (i.e., including damages related to infrastructure and traffic disruption (if relevant) and indirect and intangible damages). Capping (as used in calculating PVb – See Section 4.3) is not relevant to, and should not be applied for, the economic risk mapping.
7.0	**REFERENCES AND RESOURCES**
	References – FHRC 2010: The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University – FHRC 2005: The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University **Resources** – GN28 – Option Appraisal and the Multi-Criteria Analysis Framework – GN32 – Calculation of the Costs of Flood Risk Management Options and Measures – OPW Unit Cost Database

APPENDIX A

GLOSSARY OF ABBREVIATIONS

AAD	Annual Average Damages
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
APMR	Area of Potentially Moderate Risk (associated with Medium Priority Watercourses, or 'MPWs')
BCR	Benefit – Cost Ratio (Benefits / Costs)
CBA	Cost – Benefit Analysis
CPI	Consumer Price Index
DTM	Digital Terrain Model
FHRC	Flood Hazard Research Centre (Middlesex University, London)
HEFS	High End Future Scenario
MCA	Multi-Criteria Analysis (see Technical Methodology Note on the MCA)
MCM	Multi-Coloured Manual
MRFS	Mid-Range Future Scenario
NPVb	Net Present Value of the benefits of a potential Scheme (PVb - PVc)
OECD	Organisation of Economic Co-operation and Development
PPD	Principal Direct Damages (sum of direct damages to residential and non-residential damages)
PPP	Purchasing Power Parity
PVb	Net Present Value of Benefits (whole life, discounted benefits)
PVc	Net Present Value of Costs (whole life, discounted costs)
PVd	Net Present Value of Damages (whole life, discounted damages)

APPENDIX B

EXPLANATORY TABLE

The table below sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping and appraisal against MCA Objective 2.a), and how some of the parameters (e.g., Total damages for a given event, AAD) are calculated based on previous parameters.

The relevant sections in the Guidance Note are given in parentheses after the comment on application.

Parameter		**Application**		
		Economic CBA	**Economic Risk Mapping**	**MCA Appraisal: Objective 2.a**
1	Residential Damages	Yes (3.3)	Yes (3.3)	Yes (3.3)
2	Non-Residential Damages	Yes (3.4)	Yes (3.4)	Yes (3.4)
3	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4	Intangible Damages	Yes (3.6)	Yes (3.6)	No
5	Infrastructural Utility Damages	Yes (3.5)	Yes (3.5)	No
6	Emergency Services	Yes (3.5)	Yes (3.5)	Yes (3.5)
7	Traffic Disruption	Possibly (3.5)	Possibly (3.5)	No
8	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10	Present Value of Damages (PVd)	Discounted sum of 9 over Project Horizon	N / A	Discounted sum of 9 over Project Horizon
11	Un-capped PVb	Reduction in PVd (10) provided by Option (4.2)	N / A	Reduction in PVd (10) provided by Option (4.2)
12	Capping Value	Double Residential Property Value, or, = Non-residential Property Value (4.3)	N / A	N / A
13	Capped PVb	11, but not > 12 (4.3)	N / A	11 (4.3)
14	PVc	Whole Life Scheme Cost	N / A	Whole Life Scheme Cost
15	BCR	13 / 14 (5.1)	N / A	13 / 14 (5.1)
16	NPVb	13 - 14 (5.1)	N / A	13 - 14 (5.1)