Flood Management of the Irish Road Network

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Introduction

- Overview 2011-2018
- Assessment of the Irish Road Network
- Flood Risk Management Protocol
- Forecasting Flood Risk to Road Network
- Guidance on Flood Risk Assessment
- Implementation - Case Study examples

Interactive session – we encourage questions throughout
Core Objective

Define flood probability to the national road network, gain a more detailed understanding of which areas are at the highest risk of flooding, both now and in the future and develop management techniques to mitigate the impacts of flooding.
Research Questions

• How can we best model and represent flood hazard to roads, including climate change?

• How can we identify areas of greatest potential impact/risk?

• How can this information be best used to manage flooding, and mitigate damage, disruption and harm to people?

• How best can we offer advance warning of flooding to road users?
Results & Deliverables

- GeoPDF Mapping – ID hotspots & culvert blockage
- Analysis Tool – investigate risk statistics
- Flood Risk Management Protocol – manage & mitigate
- Forecasting & Road Alerts – preparedness
- User Guidance & Training – specify investigations
- Site Specific Investigation – mitigation
Background

• Based on RIMMAROCC Framework (ERA-NET 2010)

• Expands on SWAMP (Larsen & Pihil 2010) which highlighted risks from surface water, using a 'depression' or 'sink' approach – Blue Spot Model.
TII Flood Mapping & Data
Flood Data & Mapping

- Historic Flooding
  - Floodmaps.ie + Consultation

- Fluvial
  - 1% AEP & 0.1% AEP Extent

- Coastal (Extreme Sea Levels)
  - 0.5% & 0.1% AEP Extent

- Pluvial
  - Multiple AEP
  - Depth, Velocity & Hazard
Pluvial Mapping

- Use of NRA LiDAR
- JFlow+ full 2D SWE – velocity, depth & hazard
- 1% & 0.5% AEP 1hr duration
- 1% & 0.5% AEP 6hr duration
- Variable % Runoff
- Urban Drainage 12mm p/h
- Variable Manning’s grid
The new raster grids
Climate change adaptation

- Identify areas that are particularly sensitive to changes in rainfall
  - Difference between 100 year and 200 year return period rainfall
  - Extent of the difference (above threshold) used to highlight sensitivity
Strategic flood risk analysis

- Receptor Data
  - 5000km carriageway

- Linear Stats
  - 100m segments attributed
    - Maximum Depth
    - Maximum Velocity
    - Maximum Hazard
    - Climate Change Sensitivity
    - Traffic Exposure (SW hazard * Mean Daily Traffic)
Culvert Blockage

• For 50 locations across the country, simulations were completed with major structures (bridges or culverts conveying watercourses) modelled as blocked and un-blocked.
TII Flood Risk Management Protocol
Application of the Protocol

- The Protocol Assessment is initially based upon the flood risk metrics and flood history derived from the strategic tool.
- The aim is to allow an individual appraisal of sites that have been highlighted as potentially being at risk of flooding.
- Involves four phases of investigation and is centred around deriving a meaningful interpretation of the risk metrics concluding with mitigation and management options.
Flood Risk to Roads Protocol

Flood Risk Management Protocol for Roads
Use the flood risk to roads protocol to identify and prioritise areas at elevated flood risk and identify an appropriate course of action for managing or mitigating the flood risk.

Index Geo-PDFs
Click on this link to start up the national index map, and click on a county. This will load the roads themed by an overall flood risk score with orange and red squares having higher risk. Click on a prioritised area.

Protocol Assessment Template
Click on this link to open the guidance for following the 5 steps of an assessment for your prioritised area and start filling in following the following steps:

1) Model
2) Hydrological
3) Coastal
4) Other
5) Combined

Check if historical experience of flooding & expose the historical evidence.
Is there evidence of generalised periods due to a E14 or D1D (is the location currently party to a Minor Works Application? Is it being studied as part of the ‘OPW CLEAM Programme’?)

Inspect the detailed GeolMap at the 1:5000 scale – what are the main sources of prior flooding?

Check the velocityHave Are there significant proportions of waterways? Are they prone to close to culverts or embankments?

Do the efficiency of modelling steps of flooding (event) indicate building up the velocity of a client?

Does the proposed response with increased storm water runoff change from 3 hour to 6 hours?

Do the maps indicate climate change sensitively in drainage areas affected by infrastructure activities?

Use appropriate site risk check sheets and follow protocol assessment template.

S1 Visit to check assets check site vulnerable to scour
S2 Visit to check assets check site vulnerable to outflow
S3 Visit to check flood risk from brine assets
S4 Visit to check drainage capacity

Are the action recommendations?

S3

Consider
1. Flood Warning using Flood Foresight or
2. Maintenance:
Then prepare detailed plan of action under Phase 4

S1

Brief for tender to consultants etc

Capacity building training so assessment can be undertaken internally

S2

Permit approval and quality management

S3

Detail specialist requirements of phase 3 study, which may include:
FHA, hydrology, meteorology
Other Section (to requirements)
Drainage requirements
ANRA/ priority to SRA/MSAC

Can all elements be completed in-house?

S4

Separate guidance:
Flow charts for
Detailed FHA
Hydrological Analysis
Hydraulic Modelling

Management & Mitigation

Assets
- Water assets
- Road assets
- Highway assets

Drainage
- Complete drainage assessment
- Drainage design cost and benefits using SCOT tool
- Section 60-65 solution

Flood Warning
- Can electronic signage be installed where the expected event is high?
- Can mobile phones be used to issue warning in terms of high potential exposure?

Flood Foresight
- Rainfall forecast (0-7 days)
- Flood Forecasting
- Flood Footprint Output
- Route alerting
- Current forecast (0-10 days)

Data available through web app, API or FTP download
Application of the Protocol

PHASE 1 – Initial Assessment
- Familiarise and use all available information to understand the site and characteristics of the flooding;

PHASE 2 – Site Visit
- Further assess potential cause/mechanism of flooding;
- Complete drainage, culvert or bridge assessment;
- Trigger Detailed Assessment if required.

PHASE 3 – Detailed Assessment
- Bespoke assessment using appropriate methods
- Can include detailed modelling
- Feasibility – Benefit Cost Analysis
- Outline Design

PHASE 4 – Mitigation and Management
- Clearly outline management and mitigation measures and recommendations
- Detailed Design/Construction
TII FRA Guidance

Flood Risk Investigation
Hydrological Estimation

Tidal, Fluvial or combined issue?

Tidal
- Assess Suitable Estimation Methods
  - Refer to CFGRAM/CPSS
  - If in complex estuary, far from ICPS point then;
  - Investigate tidal gauge data availability & conduct ES/WSL analysis or models.
  - For all sites consider if wave overtopping analysis required.
- Understand location and assessment needs.

Fluvial
- Assess Suitable Estimation Methods
  - Size of catchment
  - Gauged or Ungauged
  - Urban or rural
  - Karst
  - Arterial Drainage
  - Controlled/Attenuation
  - Hydrograph required?
- Understand catchment and specify suitable methods.

Further Guidance:
- TII HD 45/15 Method E
- Environment Agency Fluvial Design Guide Chapter 2
- OPW FSU Guidance
- OPW Section 50 Guidance
- IH124
- FSR
- Eurotop manual

Consider Uncertainty
- FSE @ 66 & 95% CI (depending on estimation method and S50 requirement)
- Or Sensitivity Analysis

Use Published Tidal Data (OPW/ICPS) or Undertake Bespoke Analysis (designed for climate change)

Undertake high flow analysis using a suite of methods and assess which method is to be used as final design guidance.

Apply Climate Change Factors
- Refer to OPW and TII Standards

Reporting and Delivery
- Estimation results feed into hydraulic model
- Possible calibration feedback once design levels/extent calculated
Hydraulic modelling spec

CONCEPTUAL SOURCE-PATHWAY-RECEPTOR MODEL
- Ensure the system is understood/conceptualised to allow correct approach decision making.

CHOOSE MODELLING APPROACH
- Level of complexity & out of bank flow paths
- Are storage & flow mechanisms relevant?
- Required accuracy
- Urbanised catchment; where SW system is important
- Data available
- Time & resources available
- Type of mitigation solution; storage or diversion etc?
1D ONLY MODEL
2D ONLY MODEL
1D/2D LINKED MODEL
INTEGRATED MODEL (include surface water system with 1D/2D)

FURTHER GUIDANCE:
- TII HD 45/15 Method F
- Environment Agency Fluvial Design Guide Table 7.6
- ARR Project 15 Report (Section 2)

COLLECT MORE DATA
- Replace poor quality data
- Collect new data to support modelling approach
- Collect observations from recent flood events

ASSESS MODEL FITNESS FOR PURPOSE
- Model proven & calibrating
- Does model adequately represent flood mechanism/interaction?
- Does model match observations?

NO

UPGRADE MODELS/BUILD NEW MODELS
- Re-assess model conceptualisation, schematisation and modelling approach.
- Implement changes/model construction.

YES

MODELLING APPROACH ACCEPTABLE
- Re-integrate with main process flow chart

REPORTING AND QA
- Technical report / study conclusions fit for purpose
- Clear deliverables suited to end user
- Model handover/record

TII
Bonneagar Iompair Éireann
Transport Infrastructure Ireland
JBA consulting
Near real-time and forecast rainfall and flood data for riverine flooding

Enables flood early warning and improved targeting of mitigation and response activities
Rainfall Screening

13 March Forecast for the 14 March 2018

- Rainfall amounts:
  - 10-20mm N and W
  - 20-50mm S and E

- Goes beyond rainfall forecasting
- Provides forecast flood inundation maps
- Allows custom impact forecasting
- Enables early action to reduce disruption/loss
Rainfall Rarity Screening

13 March Forecast for the 14 March 2018

- Where is the added value?....
  - Rarity assessment
- 2-yr RP exceeded SE coast
- Dublin, Carlow and Wicklow
Forecast Flood Footprint

13 March Forecast for the 15-17 March 2018

- 2-yr RP exceeded SE coast
- 20-yr RP exceeded only for the 15th March at those basins
Potential Impacts to roads

Dublin, Carlow and Wicklow
Summary

- Research & Case Studies disseminated
  - Conferences for OPW & TII
  - Training for Road Design Offices
  - Peer reviewed paper in Journal of Infrastructure & Asset Management

- All National Road Design Offices in receipt of data
  - Use in planning for strategic improvements

- Linking with Climate Action Regional Offices (CAROs)
  - Use in maintenance and operations

- Foresight integration with operational web apps - TII

- Focus on implementation – site specific studies
Case Study
M4 Kilcock/Maynooth
M4 Kilcock/Maynooth - 2018

• Flood risk and options review M4 Kilcock - Maynooth.
• Ranked in top 5% national routes at risk of flooding. Sensitive to fluvial, pluvial and therefore climate change.
• This study aims to;
  • Quantify to TII the flood risks to the M4 between Kilcock and Maynooth Towns.
  • Investigate potential mitigation measures to increase network resilience
M4 Historic Flooding

- Driver for the study was the 21-22 November 2017 rainfall event.
- 50mm rain depth over 10hrs – circa 5% AEP (20yr)
M4 Detailed Assessment

• Further detailed fluvial and pluvial modelling required

• Study split into two investigative areas;
  • Kilcock – Pluvial source, 2D TuFLOW model with conduits (culverts) under M4
  • Maynooth – Fluvial and Pluvial sources, 1D/2D linked model (ESTRY/TuFLOW)

• Rainfall 12hr duration 5% AEP - 52mm (Met Eireann DDF)

• Hydrology – Flows taken from CFRAM (FSU)

<table>
<thead>
<tr>
<th>Annual Exceedance Probability (%)</th>
<th>Peak Flow (m³/s) Roestown</th>
<th>Peak Flow (m³/s) Lyreen</th>
<th>Peak Flow (m³/s) Roosk / Meadowbrook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qmed (2yr)</td>
<td>2.49</td>
<td>7.77</td>
<td>1.49</td>
</tr>
<tr>
<td>5% (20yr)</td>
<td>5.43</td>
<td>16.21</td>
<td>3.25</td>
</tr>
<tr>
<td>2% (50yr)</td>
<td>6.92</td>
<td>20.32</td>
<td>4.14</td>
</tr>
<tr>
<td>1% (100yr)</td>
<td>8.27</td>
<td>27.44</td>
<td>5.05</td>
</tr>
<tr>
<td>0.1% (1000yr)</td>
<td>14.71</td>
<td>40.95</td>
<td>8.82</td>
</tr>
</tbody>
</table>
M4 Detailed Assessment

- Model Setup – 2D Rain on Grid & rain + 1D/2D Linked Model
M4 Detailed Assessment

KILCOCK

- Pluvial runoff from third party lands onto the highway.
- Local field drainage culverts are under capacity & spill onto highway.
M4 Detailed Assessment

MAYNOOTH

- Fluvial risk from Lyreen is primary source – culvert capacity & overland flow onto highway.
- Secondary source is pluvial runoff from third party lands.
## M4 Mitigation - Ongoing

<table>
<thead>
<tr>
<th>Screening of Flood Risk Management Options</th>
<th>Comments</th>
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</table>
| Existing                                  | • Planning System and Flood Risk Management Guidelines  
                                          • Channel / flood defence maintenance works / programme |
| Non-Structural Measures                    | • Carry out targeted public awareness and preparedness campaign  
                                          • Early warning system (Flood Foresight) & Flood Emergency Response Plan |
| Structural Measures                        | • **Flood Storage – Lyreen catchment**  
                                          • **Natural Flood Management Measures – Lyreen & Kilcock**  
                                          • Flood Storage – Kilcock catchment  
                                          • Re-instatement of culvert @ MP 17.24  
                                          • Upstream Storage – Lyreen catchment  
                                          • Re-size critical structures – Lyreen upstream catchment  
                                          • Re-size critical structures – Kilcock catchment |
Figure 6-2: Flood Impacts - 50year Fluvial Event - Resizing critical structures Lyreen
Problem not just related to carriageway drainage.
Initial solutions prevent flooding to M4 but increase extent either upstream or downstream.
National FRA data must be supplemented by detailed modelling to fully understand mechanism and investigate mitigation options.
Other local factors need to be considered;
  • Pluvial inputs from third party lands
  • Culverts
  • Outfalls and network operation
  • Holistic approach – reduction of flow is important
Mitigation will involve third parties – OPW and Local Authority.
Natural Flood Management may play an important role.
Case Study
N85 – New Route FRA & Section 50
N85 Road Improvement

- 2nd ranked section of N85 for flood risk
- Historic flooding (fluvial), poor adaptive capacity, erosion risk

- JBA instructed in November 2017
- New road alignment and mitigation for flood risk

- The objectives of this FRA are to:
  - Identify potential sources of flood risk;
  - Confirm the level of flood risk and identify key hydraulic features;
  - Provide Section 50 design guidance for new structures;
  - Assess the impact that the proposed development has on flood risk.
N85 Initial Investigation
N85 Baseline Results
N85 Mitigation

- Location 1 – raise road between chainage 680-700m, new culvert
- Location 2 – maintain connections, raise at chainage 1400m
- Location 3 – Levels are appropriate, new culvert required
N85 Summary

• Significant risk to existing road.
• Proposed new route interacts with Shallee floodplain.
• Resilience increased by Assumptive Approach for climate change and culvert design.
• Approach is over-adaptive and costly.
• There are alternative approaches to assessing adaptive capacity.
• Recommendations are now with designer - feasibility assessment.
Case Study
N65 Carrigahorig
N65 Carrigahorig Flooding

- MWRDO & Tipperary County Council
- Study conducted between Nov 2016 to Feb 2017
- 650m of N65 flooded at Carrigahorig for 6 weeks ‘15/16

- Flood risk investigation & mitigation study

- Objectives:
  - Identify potential sources of flood risk;
  - Examine existing flood outlines for the location and, if possible, improve upon their accuracy;
  - Inform decisions relating to the detailed design of the road;
  - Develop appropriate flood risk mitigation and management measures which will allow for the long term improvement of the site.
N65 Carrigahorig Flooding

- Source is lacustrine (lake) flooding from Lough Derg
- Groundwater is close to the surface in the project area
- Flooded in 2009 (32.05mOD) and 2015/16 (31.97mOD, long duration
- Road forms boundary with SAC and this forms a large constraint
- Existing flood mapping is not fit for purpose
N65 Carrigahorig Flooding

• Level analysis from Portumna gauge
• Fitted GEV distribution and estimated extreme lake levels
• Mapped road hazard to identify vulnerable sections
N65 Mitigation

- Standard of Protection to consider adaptive capacity / cost benefit;
- Use in decision making for route alignment or raising option;
- Road level (inc FB) not to exceed 32.8mOD (500mm less than FFL);
- SAC proximity will invoke the requirement for full Stage 2 Appropriate; Assessment, CEMP and a more onerous planning route;
- Existing culverts under road can convey Lough Derg volumes;
- However, additional high level culverts should be installed.
Overview

• Understanding of how TII is;
  • Identifying flooding hotspots
  • Using forecasting data & route alerts
  • Manage & mitigating flooding to the road

• Undertaking/specifying FRA for:
  • Road Design – Section 50 culverts & bridges
  • Road Route – assessment of impacts, levels, design
  • Investigation & mitigation of existing flooding problems
Thank you
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