Strategy for Adapting to Extreme Weather Events and Climate Change – Implementing CEDR Research into NRA's Protocols, Guidelines and Standards – Road Drainage Design

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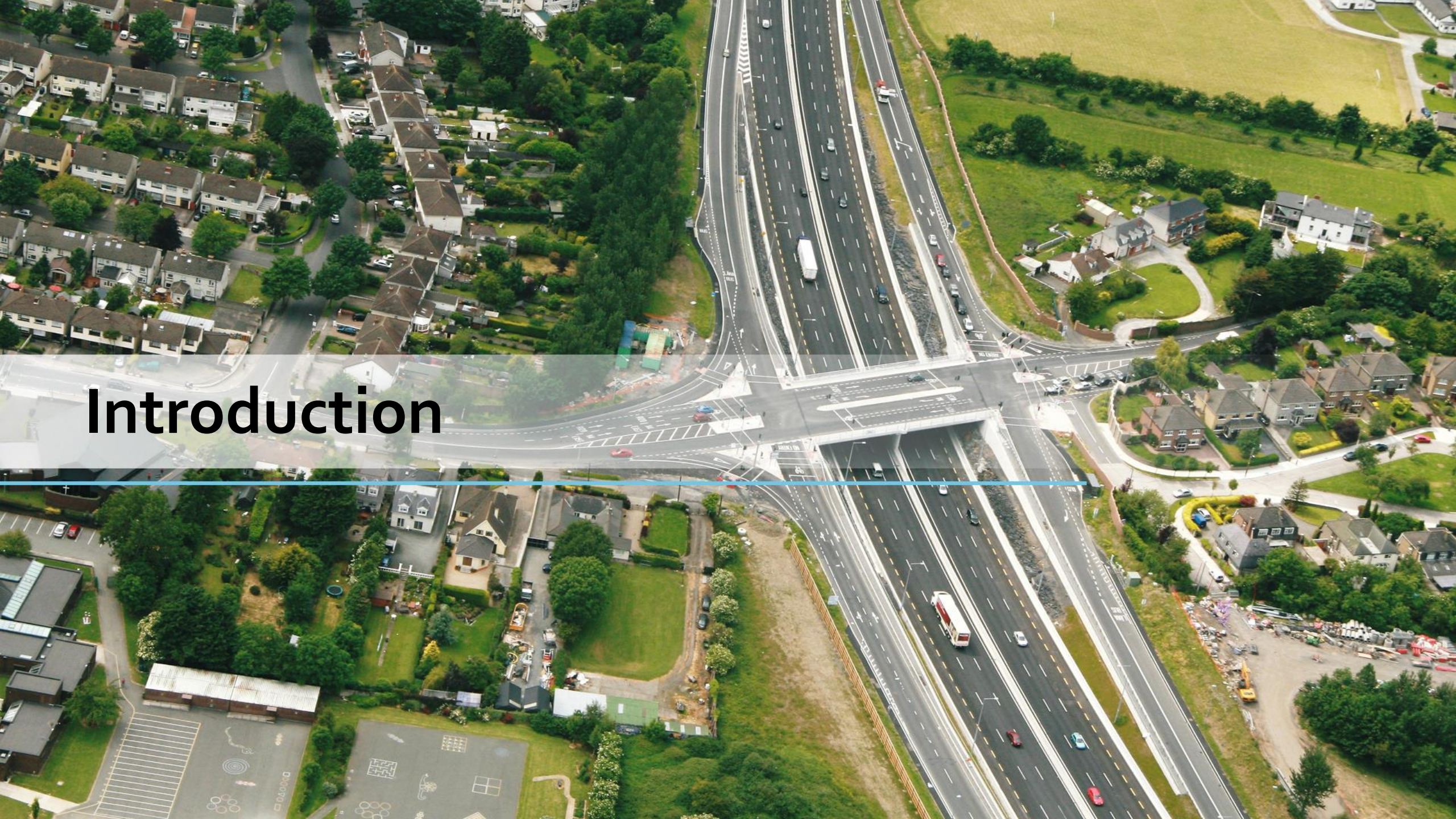
Bonneagar Iompair Éireann
Transport Infrastructure Ireland



Introduction

CEDR - Pathway for adaptation to climate change

CEDR CALLS	TII Response	Ireland National
2008 RIMAROCC: SWAMP:	Research study Commissioned flooding study.	Carbon Targets.
2012 ROADAPT CliPDaR	New Drainage Standards Accounting for climate change. Comprehensive set of flood maps Risk assessment on road network.	National Coordination Group on Severe Weather. EPA publications on Climate Change in Ireland.
2015 DeTECToR WATCH MoDBeaR	Climate Change Strategy document. Developed Sustainability Statement. Developed Country Specific Carbon Tool. Developed new forecasting tool	New Government Climate Change Unit. National Climate Change Adaption Plan for transport sector. National Climate Change Mitigation Plan.

Future Scenarios ! 2013

CEDR CALLS	TII Response	Ireland National Policy
2008: Road Owners Getting To grip with Climate Change. **RIMAROCC: Risk Management for Roads in a Changing Climate** **SWAMP: Storm Water prevention – Methods to Predict Damage from the Water Stream in and near Road Pavements in lowland Areas**	Initiated Research through Irish Universities on Drainage Design on national road network. 4 Year Post Doc Trinity. Published on TII website. In house expertise in drainage design. Commissioned research in relation to risk of flooding on national network. JBA 2 year study. Not a custom methodology in SWAMP.	Carbon Targets. GHG's. Transport big contributor to GHGs along with Agriculture and Industry. Legislation for industry and agriculture (management) but very little for transport.

Conclusions from research

- Work Practices, Assessment methodology for Groundwater Aquifers, volumetric calculations, Engagement with stakeholders.
- Road runoff contains SS, heavy metals and PAHs
- These pollutants represent a pressure on surface waters and groundwaters
- A lot of research conducted on impacts on surface waters and mitigation measures defined
- Little research on groundwater impacts – perceived risk – costly mitigation measures

Conclusions from research

- SUDS treat runoff very effectively
  - Wetlands and grassed channels
  - Lack of design information

- Groundwater is less susceptible to pollution by particulates, but remains at risk from soluble contaminants

- HAWRAT tool introduced as part of standards to assess pollutant load of runoff

- Biggest concentration of pollutants is in sediment bound phase.

- Climate Change – reviewed but little science. 20% approach questioned.

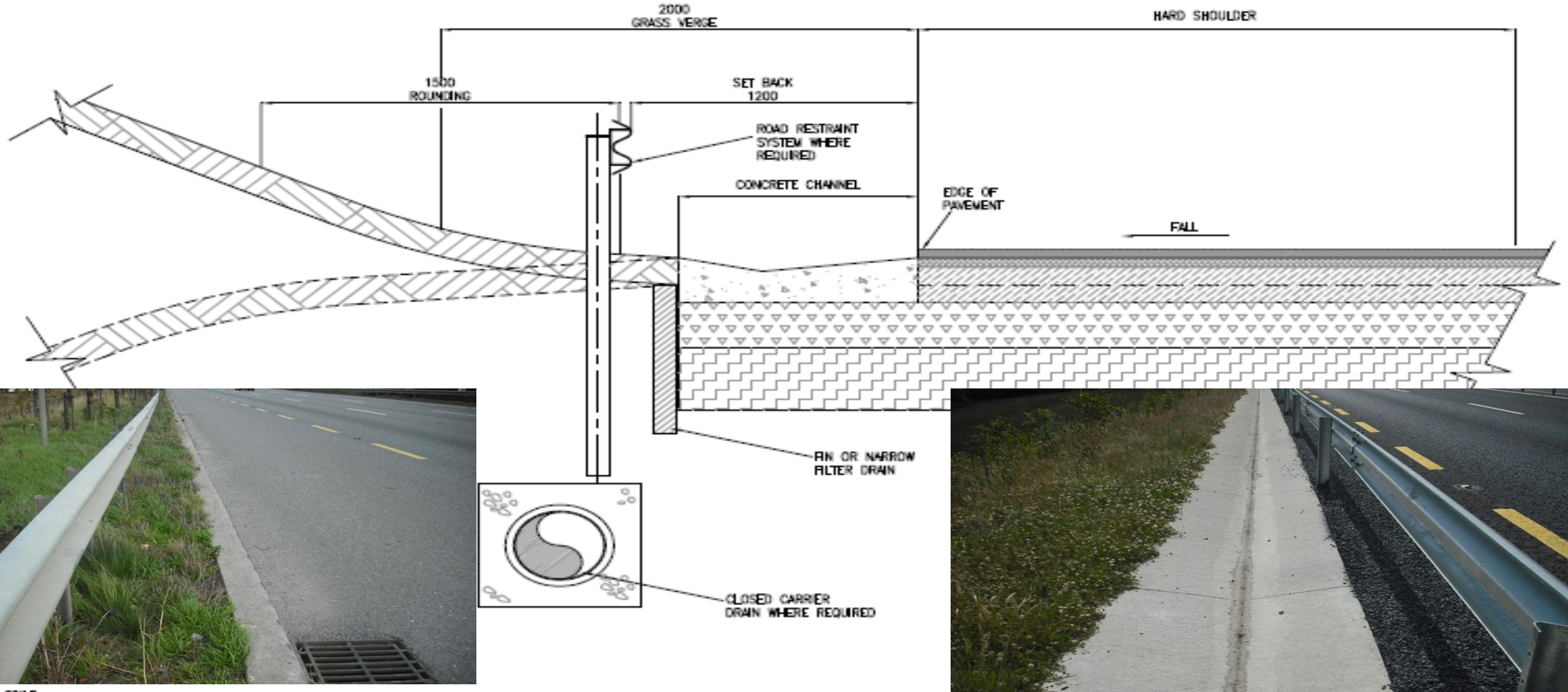
Wetland


Class 1a, 1b, 804. Material
Impermeable liner


Top Soil and grassed

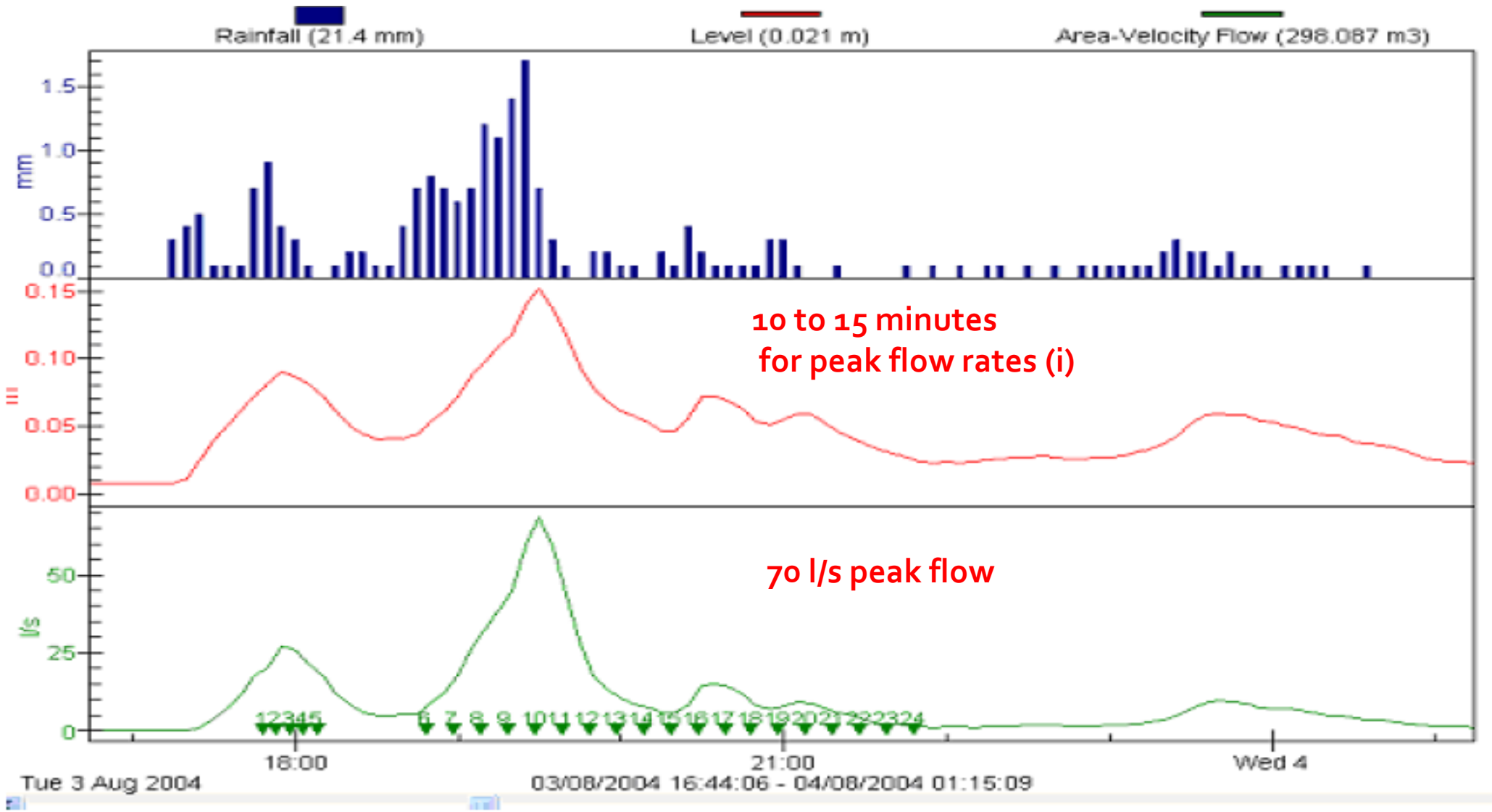
NOTES:

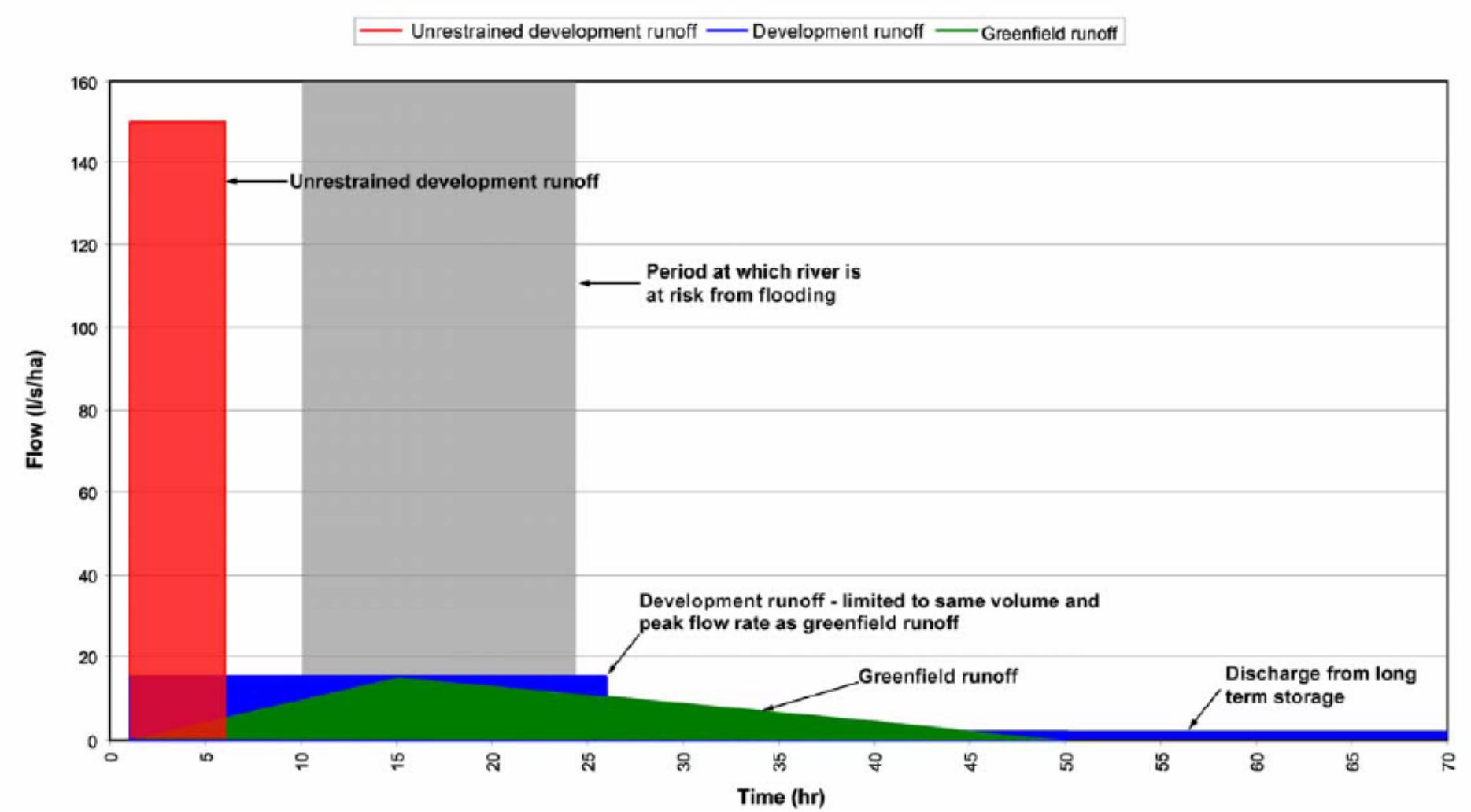
1. ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE STATED.

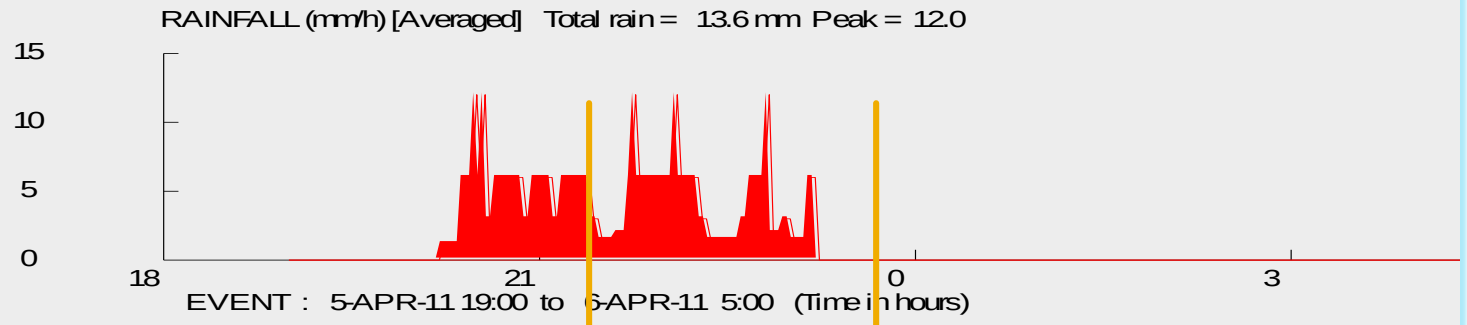


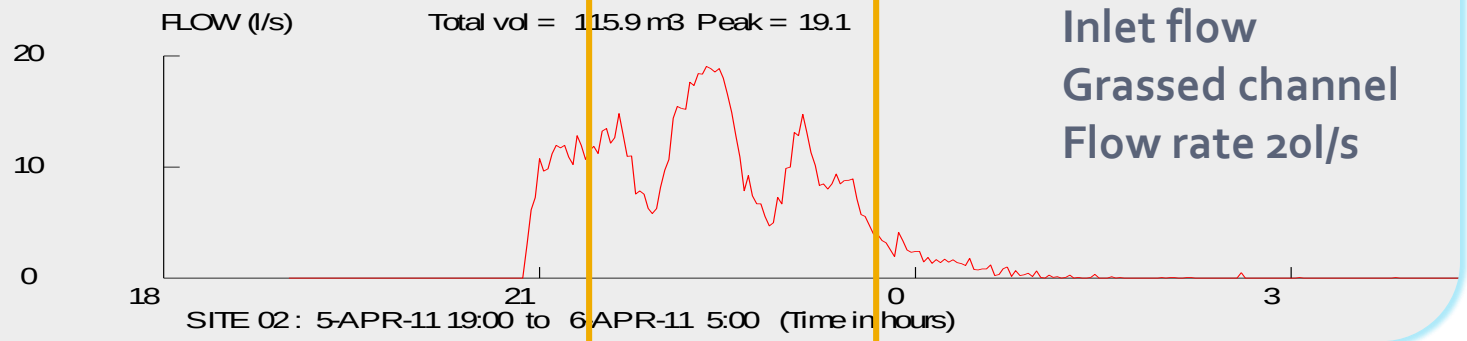
NOT TO SCALE

NRA NATIONAL ROADS AUTHORITY	ROAD CONSTRUCTION DETAILS	DRAINAGE	P2 01/08 P1 10/07 Issue Date

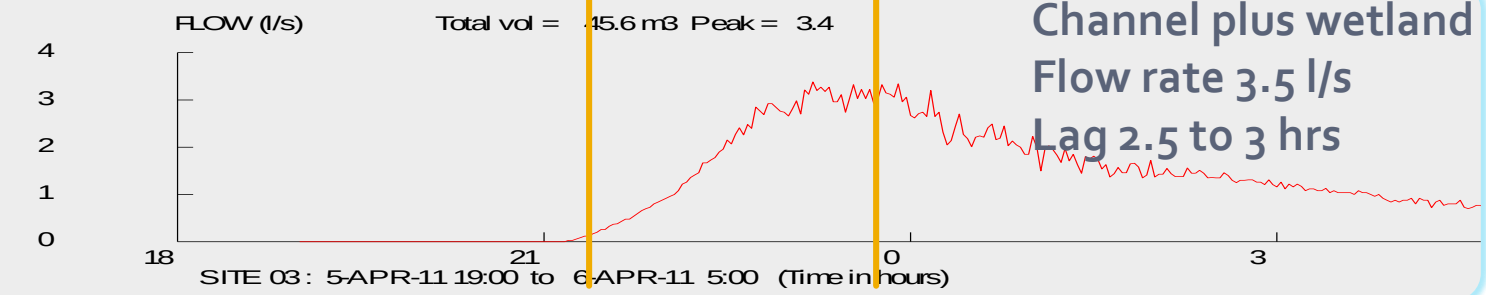

Rainfall (21.4 mm)
Level (0.021 m)
Area-Velocity Flow (298.087 m3)
mm
1.5
1.0
0.5
0.0
m
0.15
0.10
0.05
0.00
l/s
50
25
0
10 to 15 minutes
for peak flow rates (i)
70 l/s peak flow
18:00
21:00
Wed 4
Tue 3 Aug 2004
03/08/2004 16:44:06 - 04/08/2004 01:15:09


Unrestrained development runoff
Development runoff
Greenfield runoff
Flow (l/s/ha)
160
140
120
100
80
60
40
20
0
Unrestrained development runoff
Period at which river is at risk from flooding
Development runoff - limited to same volume and peak flow rate as greenfield runoff
Greenfield runoff
Discharge from long term storage
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Time (hr)





Inlet flow
Grassed channel
Flow rate 20l/s



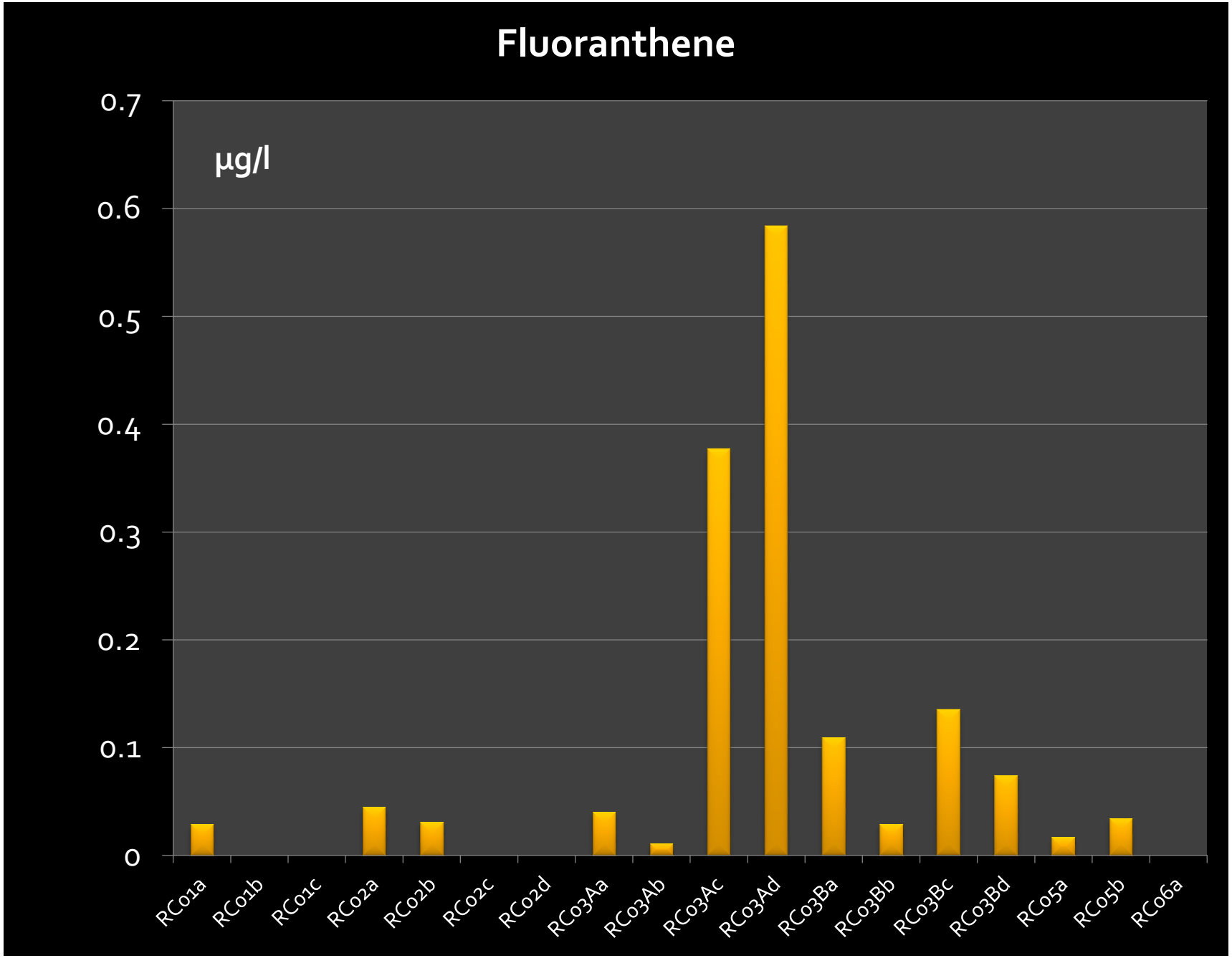
Outlet to stream
Channel plus wetland
Flow rate 3.5 l/s
Lag 2.5 to 3 hrs

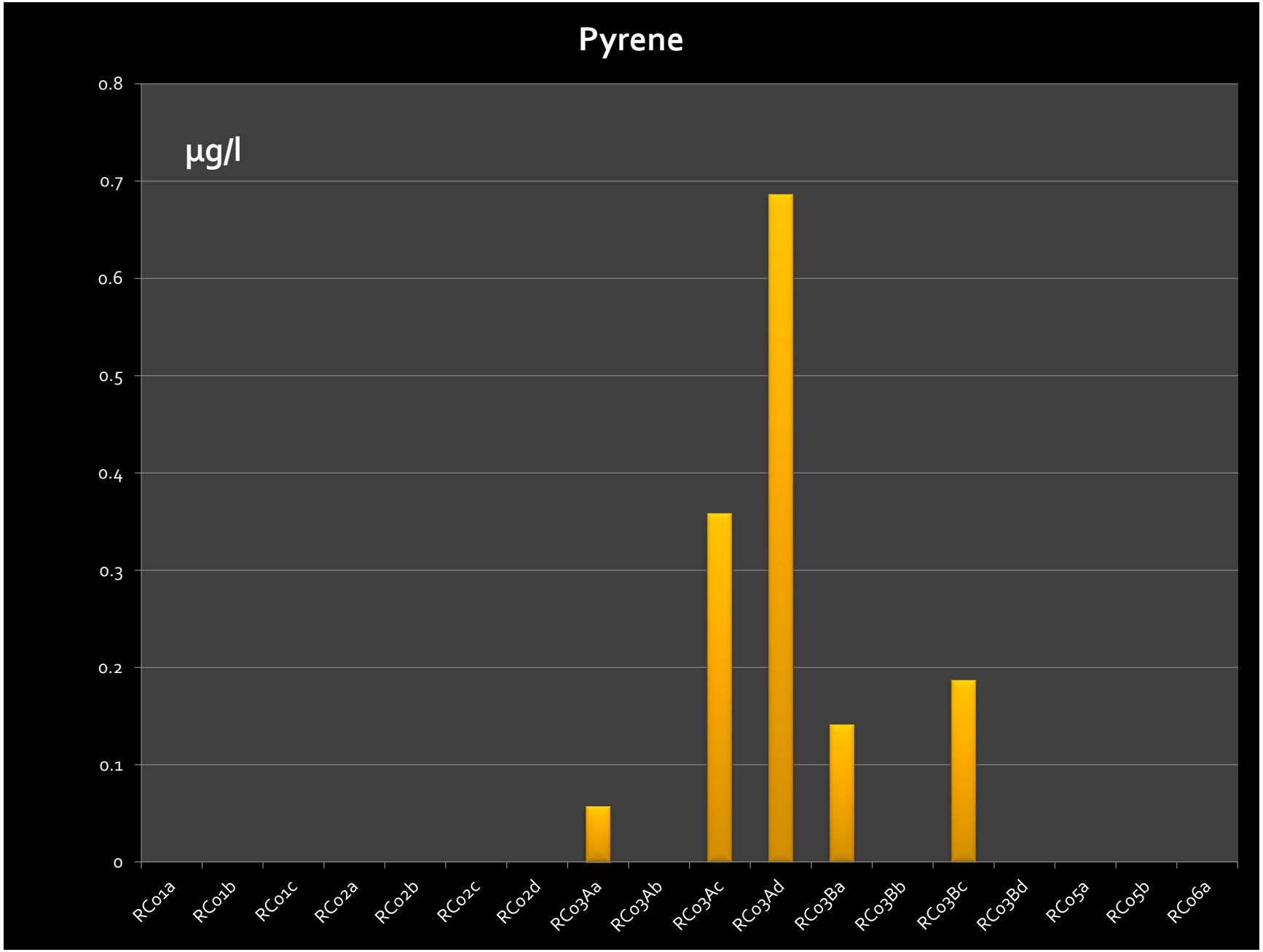
How can SUDs be used to adapt for Climate Change

- More resilient and sustainable than conventional systems
- Will treat and attenuate short duration intense summer rainfall events – these carry biggest pollutant load.
- Will restore Greenfield site conditions protecting morphology of receiving waters.
- Offer a broader biodiversity.
- Can be sized to cater for increased rainfall intensity.

Groundwater Management

- Groundwater monitoring boreholes measuring metals and PAHs
- Blanket Bog, Rainwater fed
- Karst systems
- Kildare, Fen, Groundwater Dependent Ecosystem


Fluoranthene
µg/l
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RC01a
RC01b
RC01c
RC02a
RC02b
RC02c
RC02d
RC03Aa
RC03Ab
RC03Ac
RC03Ad
RC03Ba
RC03Bb
RC03Bc
RC03Bd
RC05a
RC05b
RC06a


Pyrene
µg/l
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RC01a
RC01b
RC01c
RC02a
RC02b
RC02c
RC02d
RC03Aa
RC03Ab
RC03Ac
RC03Ad
RC03Ba
RC03Bb
RC03Bc
RC03Bd
RC05a
RC05b
RC06a

Conclusions M7 Monitoring

- Groundwaters adjacent to M7 contain:
  - Metals Zn, Pb
  - PAHs
- Motorways with heavy traffic > 70,000 AADT – require treatment of runoff to protect both surface waters and groundwaters.
- GSWC, concrete channels
- Additional treatment (wetland) prior to discharge.

Soil Functions

- **Growing food, plants, forestry.**
- **Filtering water.**
- **Controlling the rate at which rain water reaches watercourses.**
- **Storing carbon and exchanging greenhouse gases with the air.**
- **Supporting valuable habitats, plants and animals.**
- **Preserving cultural and archaeological heritage.**
- **Providing raw materials.**
- **Providing a platform for building on.**

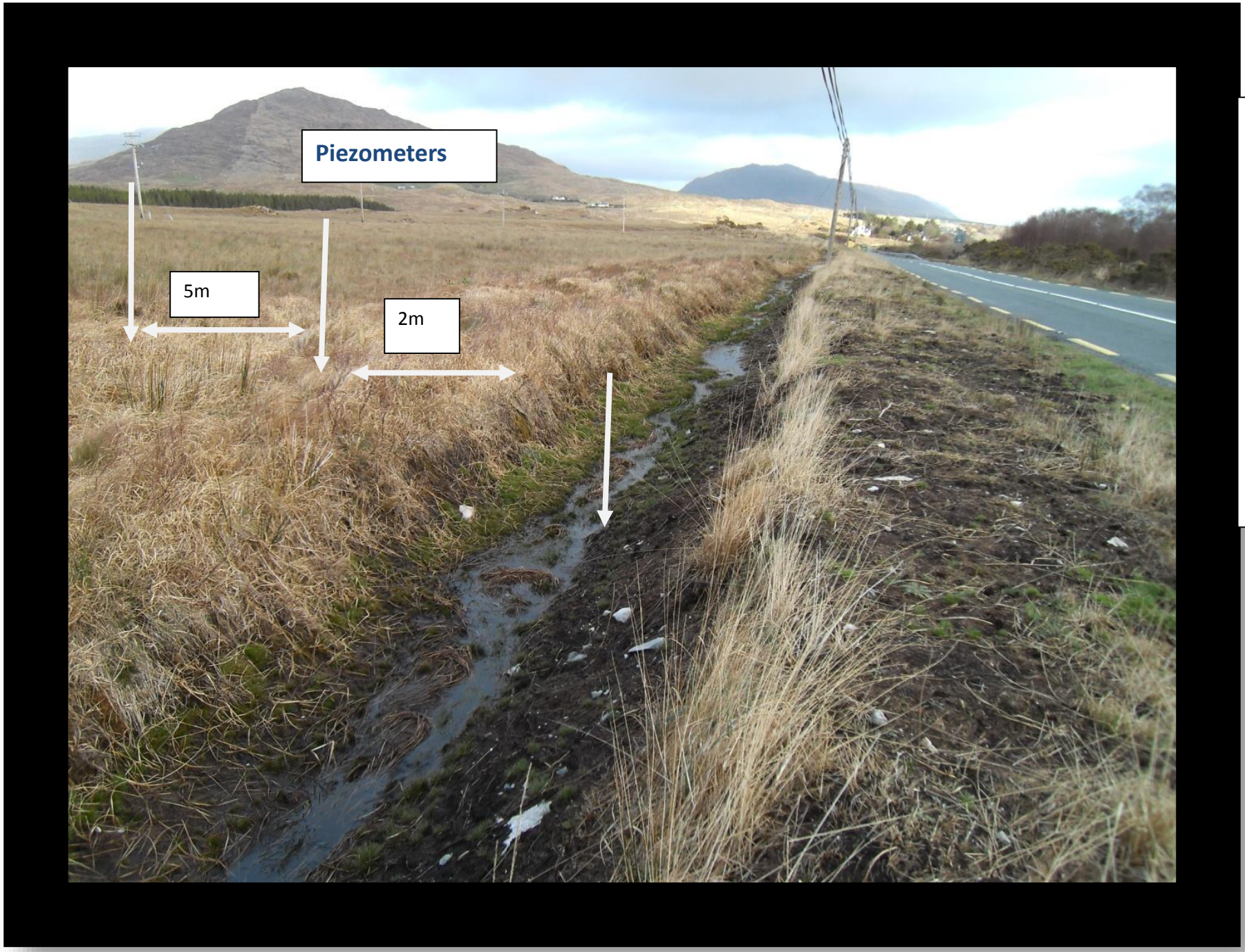
Soil degradation, therefore, will impact on:

- Water quality
- Human health
- Climate change
- Biodiversity
- Food supply.

Impacts on Blanket Bog – groundwater Dependent Ecosystems

- Rainwater fed (rather than fen or flush groundwater fed)
- Potential to dewater
- Introduce longitudinal drain by excavating peat
- Mitigation?

Trinity College Dublin



Site Investigation

Bigger groundwater component that initially thought

Mitigation

- **Longitudinal Barriers**
- **Transverse Barriers**

Climate Change Role

Blanket Bogs and Climate Change

- Major reservoir for Carbon
- Impacts relate to sealing, dewatering, earthworks, compaction, erosion (EIA Directive). How evaluate.
- Dynamics of hydrology and hydrogeology is changing – more intense rainfall, more flooding, longer droughts.
- Required to understand dynamics and propose mitigation in the light of Climate Change
- Major challenges.

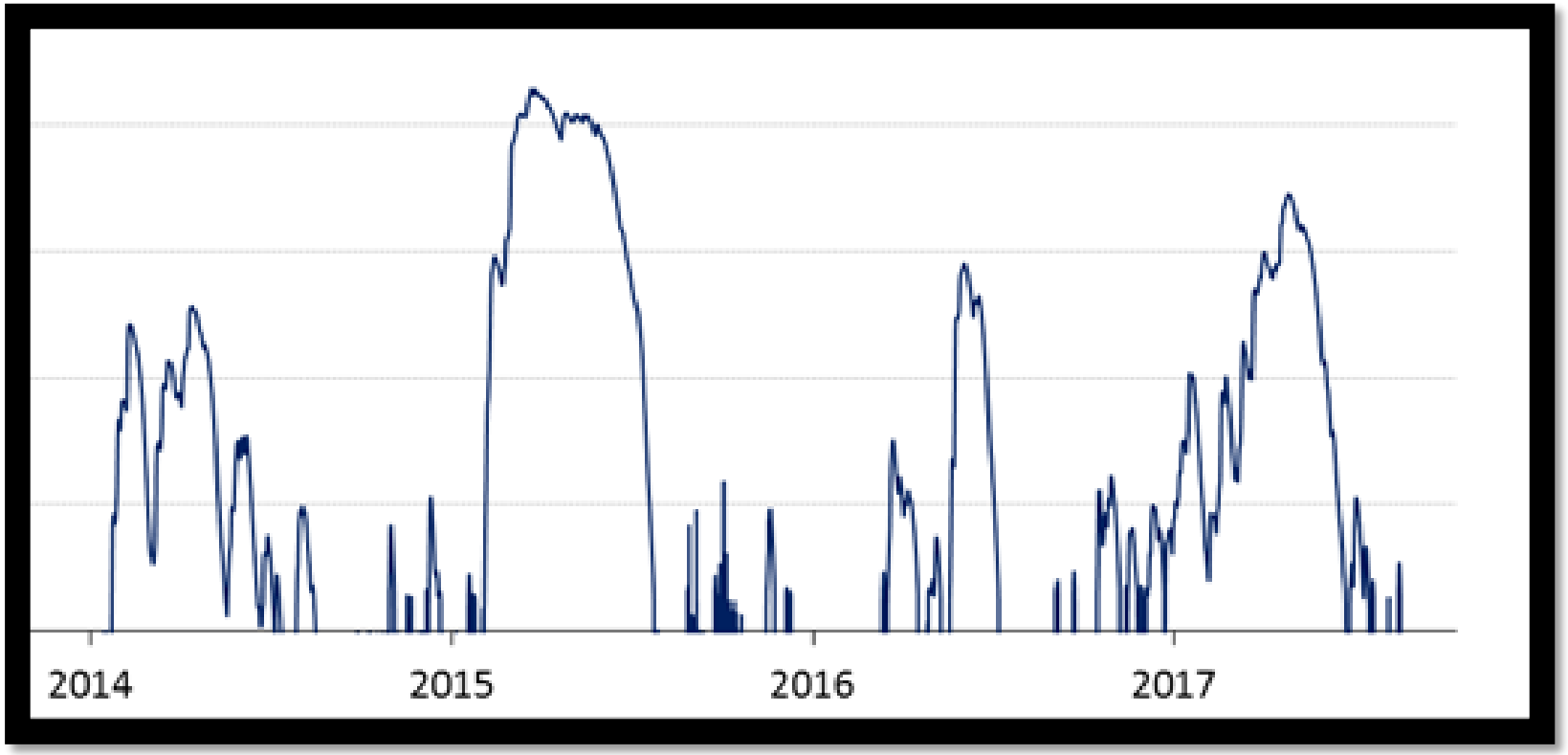
KARST

Priority Habitats – Habitats Directive

Turlough – seasonal lakes

Hydrograph for Turlough

Geological Survey of Ireland and Trinity College Dublin



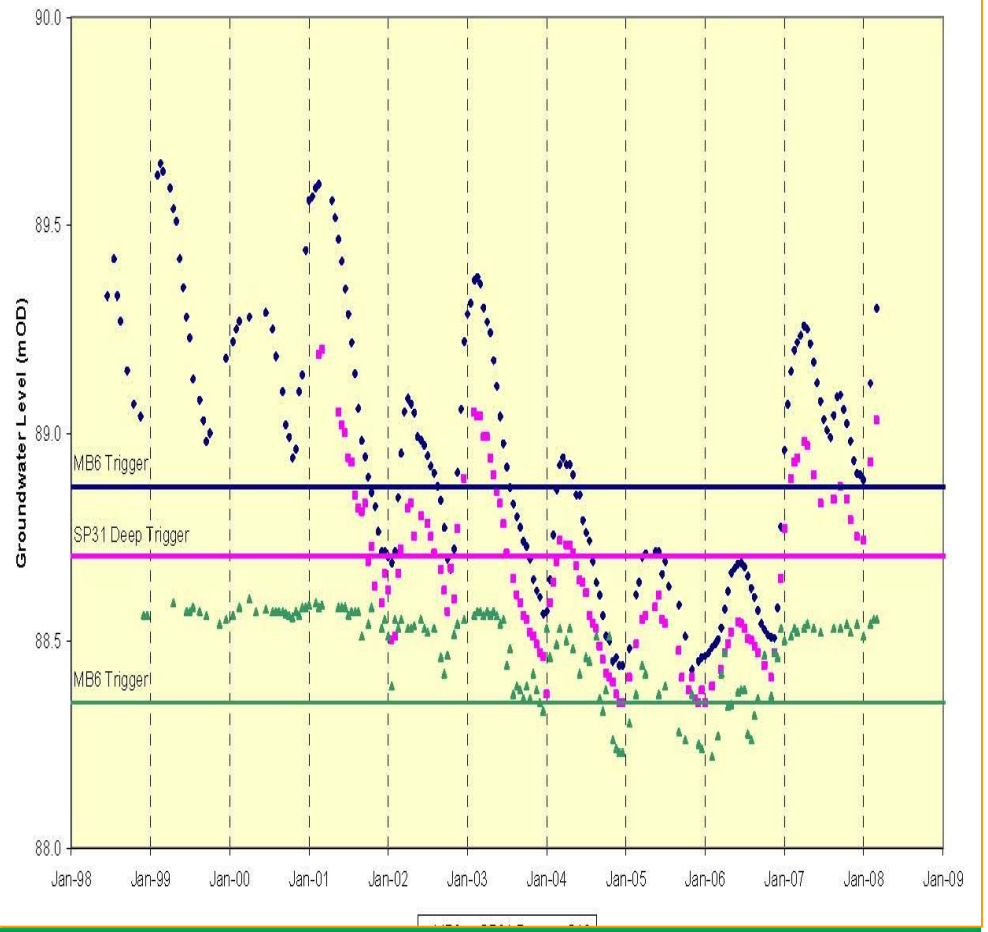
Karst Features and Climate Change

- Turloughs
  - More frequents flooding and overspilling
- Sinkholes
  - Impacted by increases in conduit flow
  - More frequent
- Coastal rise in sea level
  - Impact discharge
  - More salinity
- Several research programmes

FEN

Whorl Snail (*Vertigo Sp*)

Figure 9: Irrigation Trigger Hydrographs.

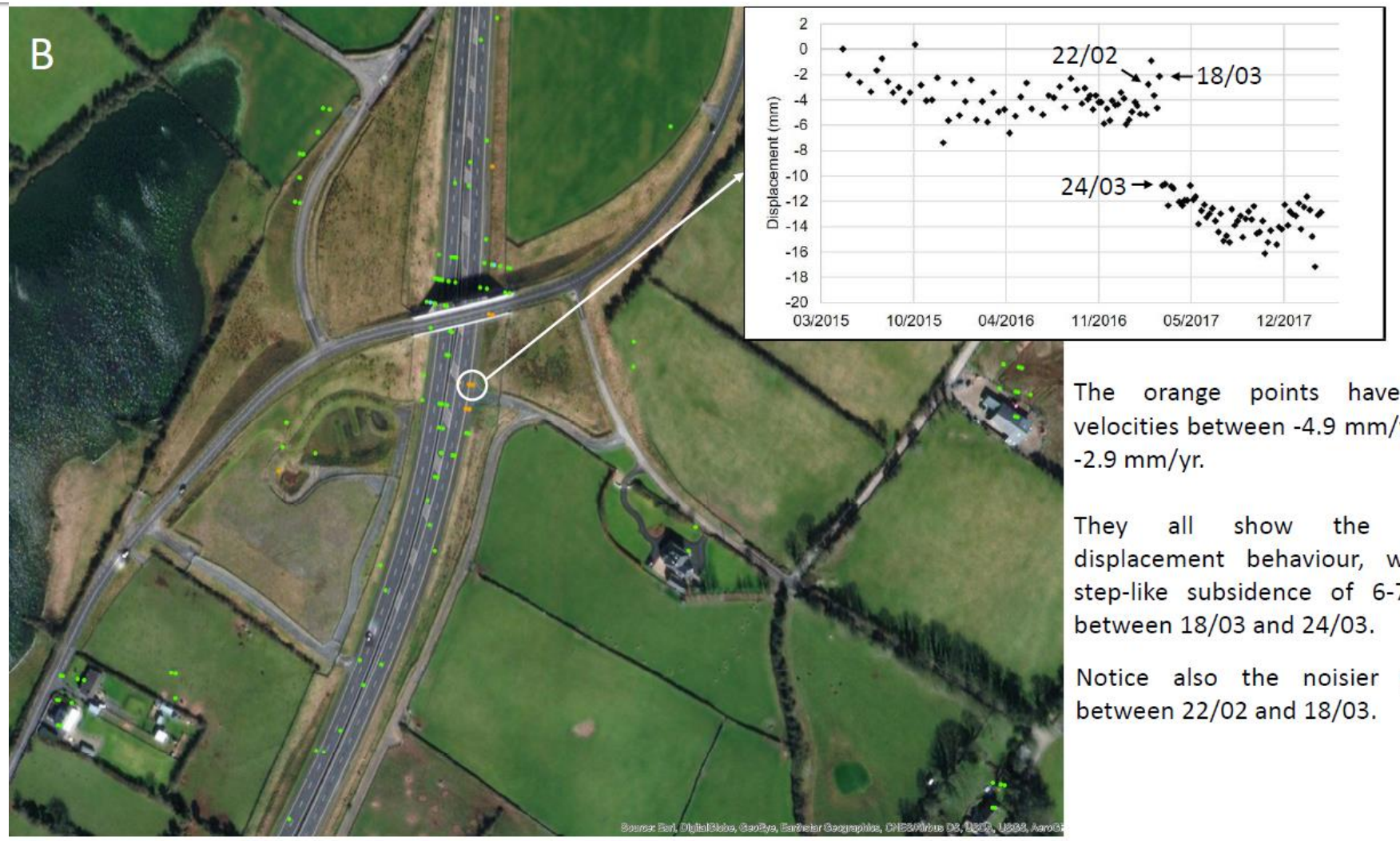


Groundwater Systems

- Groundwater dependent ecosystems
  - Dynamics are changing as a result of climate change
  - Road infrastructure interacting with these systems required to understand groundwater controls and impacts of climate change (precautionary approach)
- Difficult to predict how systems will change
  - Mitigation measures ??
  - Monitor
    - But how?

Subsidence detected with InSAR along the M18
Sentinel-1A/B PS analysis

Simone Fiaschi,
Eoghan Holohan
UCD School
of earth Sciences



The orange points have LOS velocities between -4.9 mm/yr and -2.9 mm/yr.

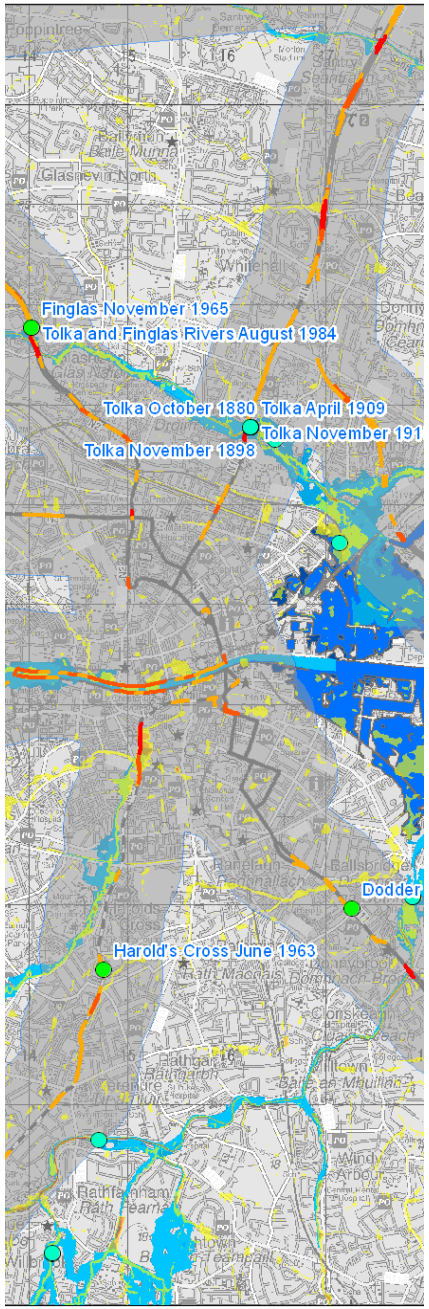
They all show the same displacement behaviour, with a step-like subsidence of 6-7 mm between 18/03 and 24/03.

Notice also the noisier points between 22/02 and 18/03.

TII Status 2012

- Very good understanding of water management on network
- Need to develop understanding of climate change and risk to road infrastructure from surface water and groundwater perspective.
- Transfer research into TII Policy Documents
- Disseminate information to Local Authorities and regional offices.

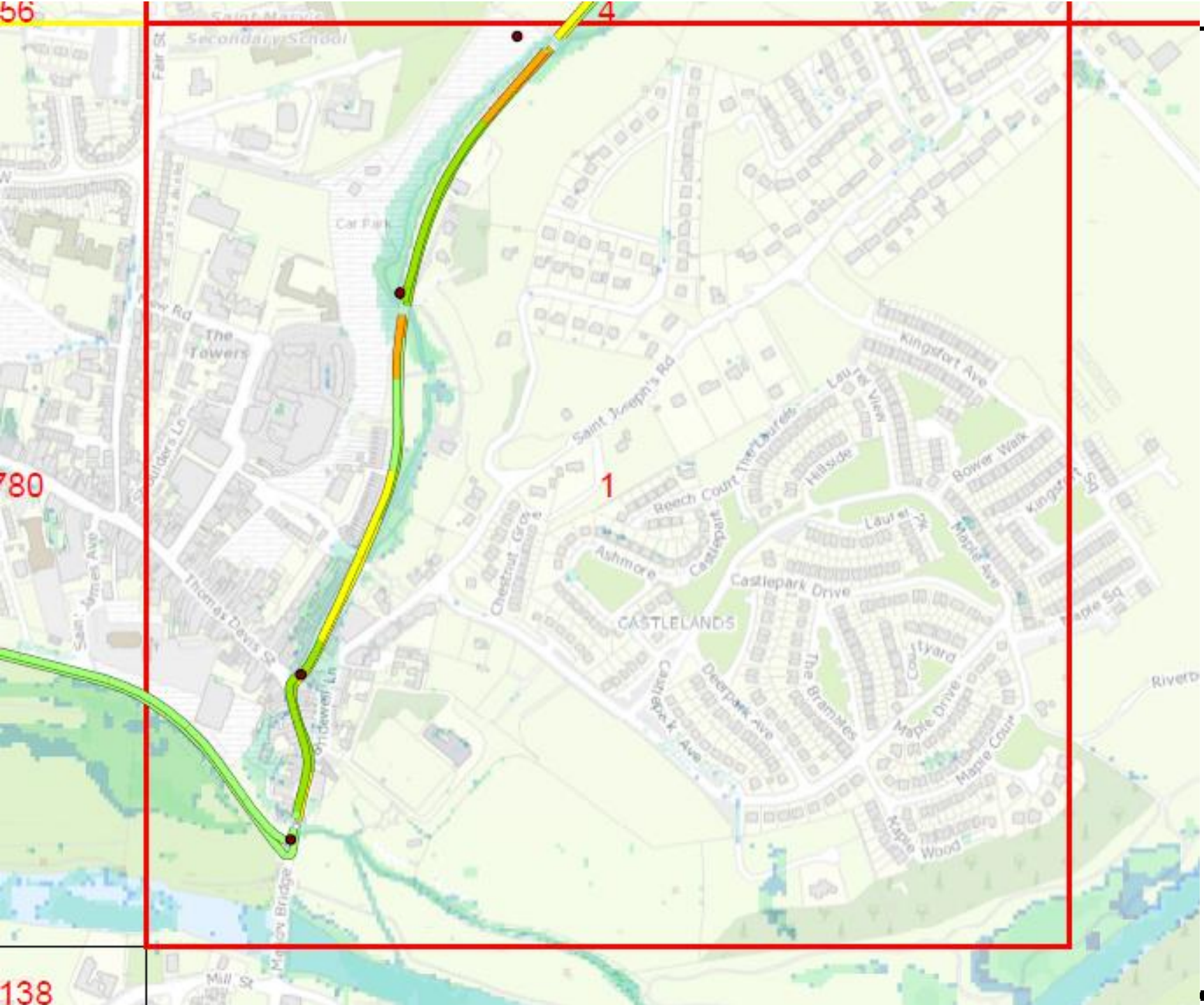
CEDR CALL	TII Response	Ireland National Policy
2012: Road Owners Adapting to Climate Change. **ROADAPT – Roads for Today, Adapted for Tomorrow** **CliPDaR - Design guideline for a transnational database of downscaled climate projection data for road impact models**	Comprehensive set of flood maps of the entire national road network and high level protocol for assessment of flood risk (RIMAROCC) Developed complete set of drainage design standard documents to account for research findings. Accounting for climate change in designs: both rainfall and actual design (SUDS). Risk assessment Roadapt.	National Coordination Group on Severe Weather. EPA publications on Climate Change in Ireland - Sectoral inputs into climate change. (Transport very high. Agriculture highest.)



LiDAR DTM

JBA has hydraulically accurate modelling of extreme flooding.

- JFLOW+ software solves the full shallow water flow equations.
- Also derived a Comprehensive Flood Map (CFM) for Ireland, covering fluvial, coastal and extreme surface water for different extreme events.
- Lidar



LEGEND

Rank of overall flood risk metric

WM_Rank_Corrected_V2

- 1 - 1000
- 1001 - 2000
- 2000-6801
- NRA Points
- Road Flooding
- Flooding within 100m

Original SW map

cwaytype2010_Length_m

- 100-250
- >250

Q100 Fluvial JBA CFM

cwaytype2010_Length_m

- 100-250
- >250

Q200 Tidal JBA CFM

cwaytype2010_Length_m

- 100-250
- >250

Climate change

ccq200_MAX

- less sensitive
- more sensitive

Peak Hazard on Carriageway

Q2V3th_MAX

- 0.00 - 0.30
- 0.31 - 0.75
- 0.76 - 1.50
- 1.51 - 2.50
- >2.5

Q100 1hr Flood Risk to People

Q100 1 hour hazard

- < 0.3
- 0.3 - 0.75 Caution
- 0.75 - 1.5 Flood Risk to Some
- 1.5-2.5 Danger to Many
- >2.5 Danger to All

Q100 1 hr Velocity m/s

Velocity (m/s)

- 0-0.1
- 0.1-0.5
- 0.5 - 1
- > 1.0

Q200 1hr Depth

depth (m)

- 0
- 0.01 - 0.1
- 0.11 - 0.3
- 0.31 - 1
- >1.0

Q200 6 hour depth

depth (m)

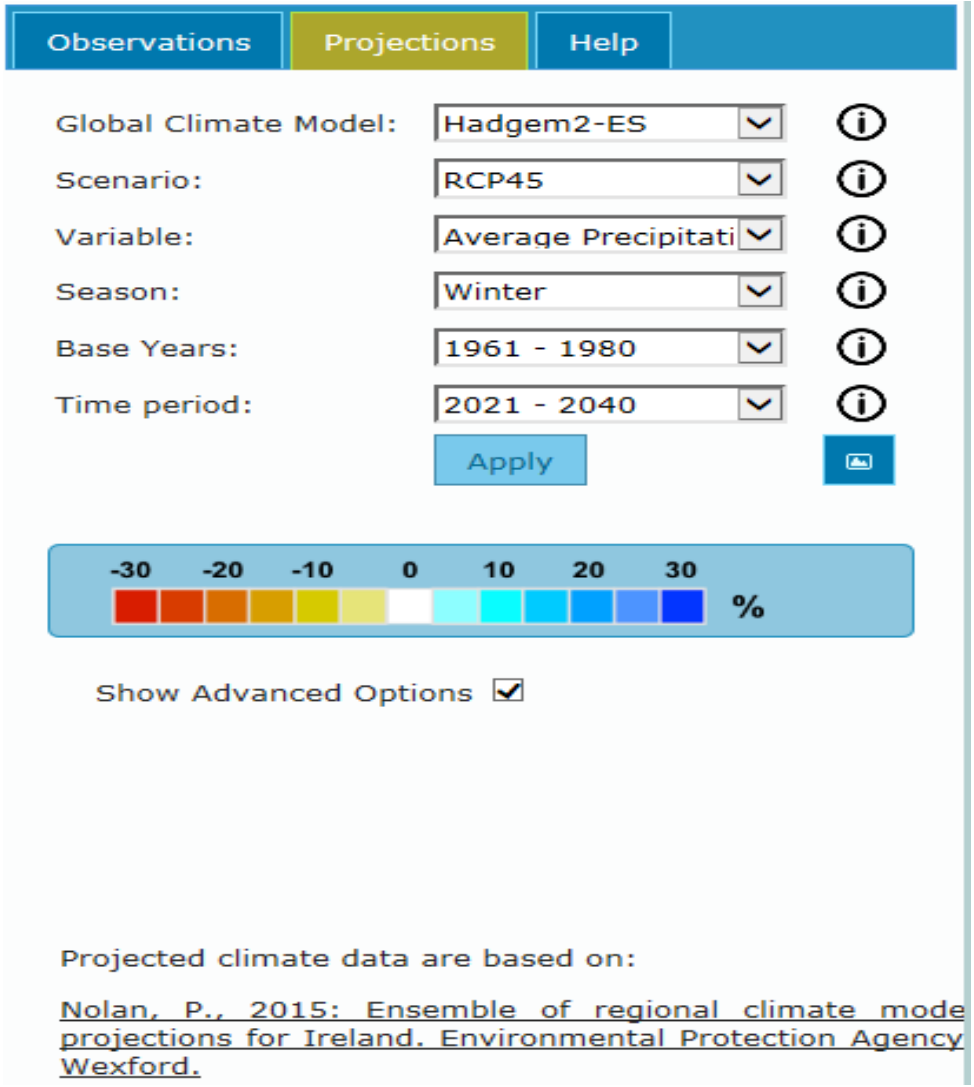
- 0
- 0.01 - 0.1
- 0.11 - 0.3
- 0.31 - 1
- >1.0

New NRA Drainage Standards

- Revised NRA Design Manual for Roads and Bridges (NRA DMRB)(1 amended and 13 new documents).

  - New Designs for SUDs elements.
  - New protocol for design process.
  - Update on volumetric calculations.

Climate Ireland EPA - Projections



Nested two Regional Climate Models (RCMs) into a set of Global Climate Models (GCMs).

RCMs

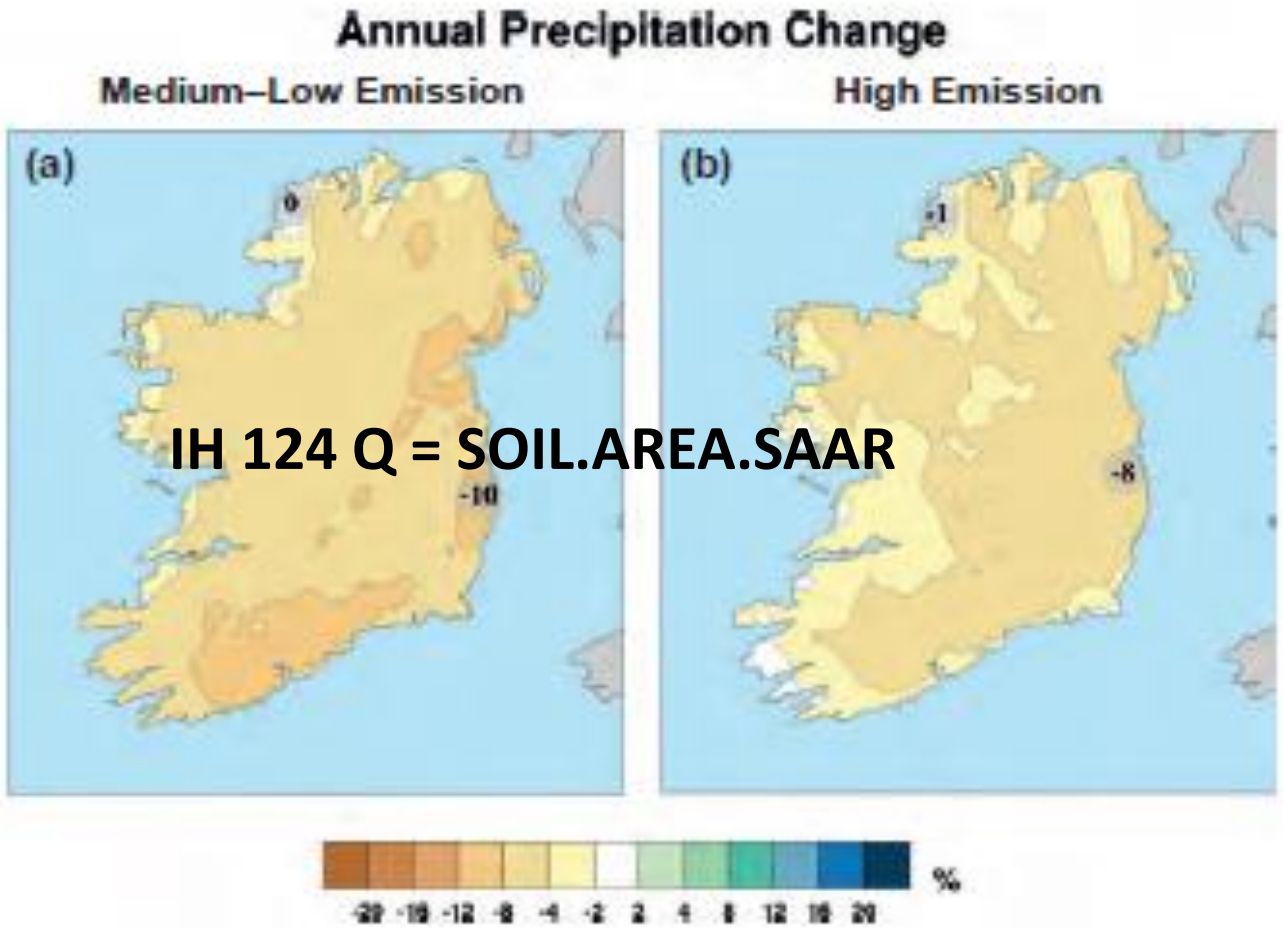
- **COSMO-CLM**
- **WRF**

GCM

- **Max Plank In ECHAM5**
- **UK Met HadGEM2-ES**
- **CGCM 3.1**
- **EC – Earth**

Simulated using IPCC scenarios

- **SRES A1B, A2, B1**
- **RCP 4.5, 8.5**



IH 124 Q = SOIL.AREA.SAAR

Ensemble of regional climate model projections for Ireland

Author: Paul Nolan, Irish Centre for High-End Computing and Meteorology and Climate Centre, School of Mathematical Sciences, University College Dublin

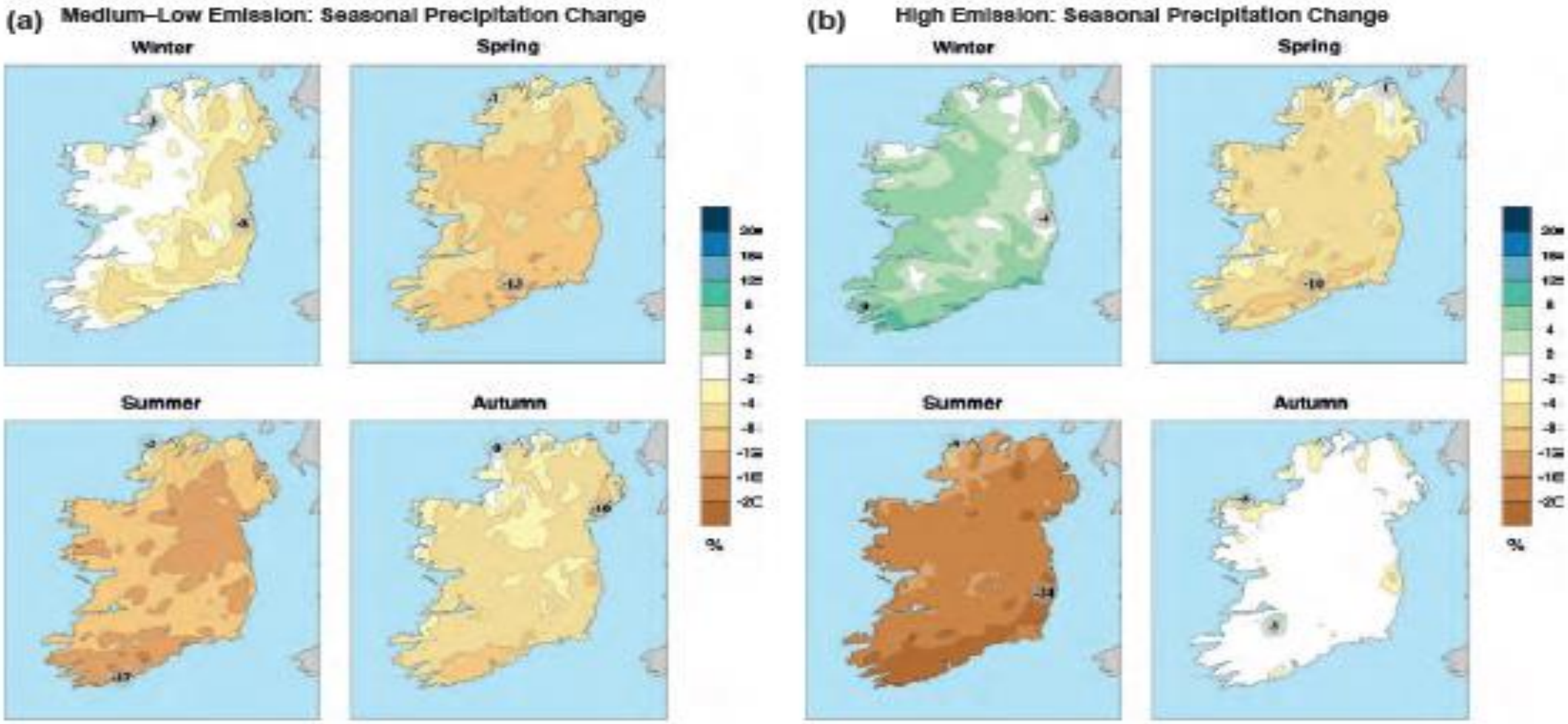


Figure 3.5. Projected changes (%) in seasonal precipitation. (a) Medium- to low-emission scenario; (b) high-emission scenario. In each case, the future period 2041–2060 is compared with the past period 1981–2000.

TII Status 2015

- Better understanding of climate change and risk to road infrastructure
- New Drainage Standards
  - Accounting for climate change
  - Risk assessment procedure for groundwater and surface water impacts
- Detailed flood maps covering entire network
- Missing
  - Detailed climate change – how embed into engineering designs
  - Climate Change strategy
  - Protocol for retrofit

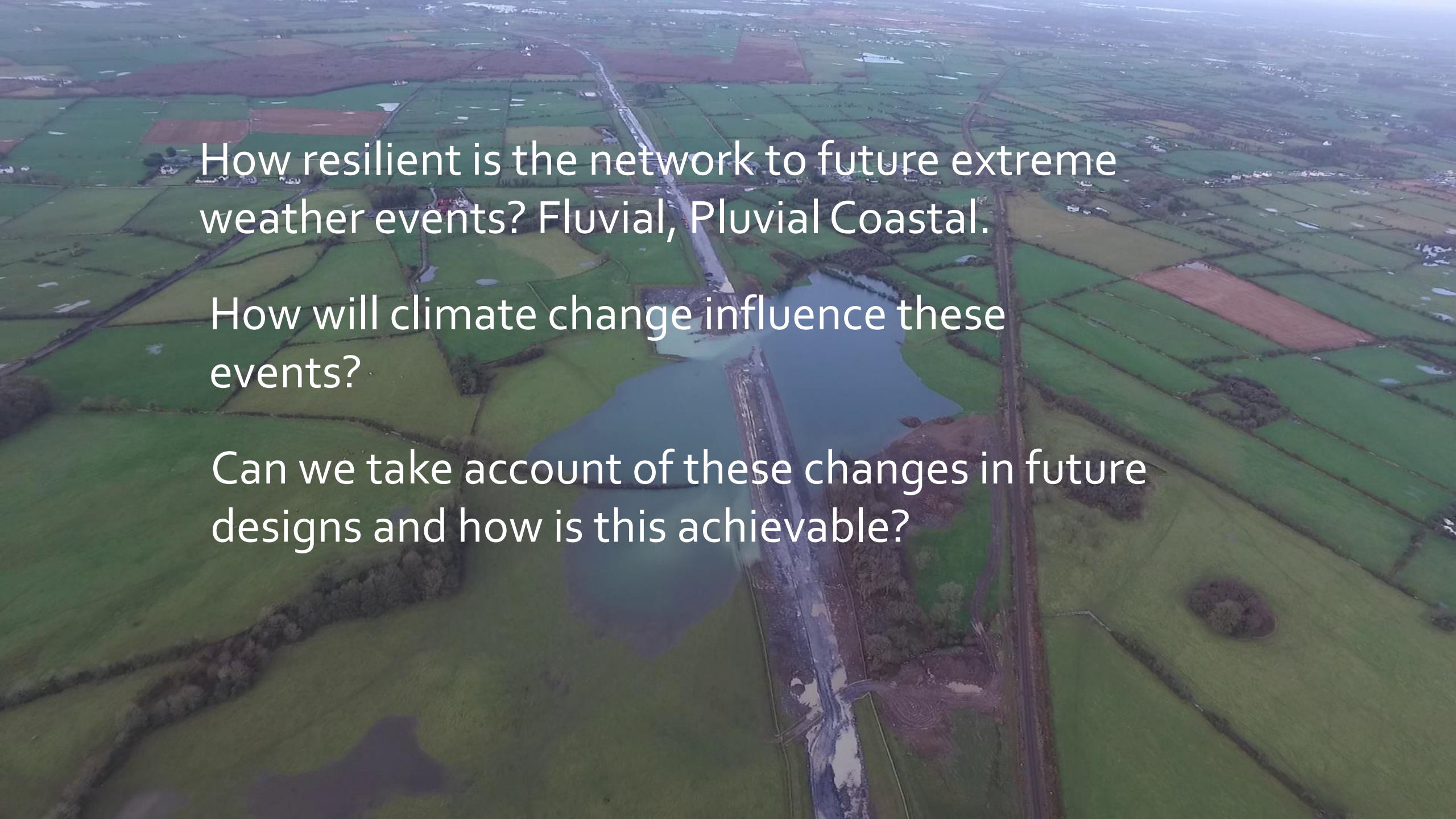
CEDR CALL	TII Response	Ireland National Policy
2015: Climate Change: From Desk to Road **DeTECToR – Decision support tools for embedding climate change thinking on road** **WATCH – Water management for road authorities in the face of Climate Change** **MoDBeaR – Mobility Management and Driver Behaviour Research**	Developed Climate Change Strategy document. Published. Developed Sustainability Statement. Developed Country Specific Carbon Tool. Developed new forecasting tool for predicting network flooding on a detailed level (individual sections of motorway. New detailed protocol for assessment of mitigation measures.	New Government Climate Change Unit. National Climate Change Adaption Plan for transport sector. National Climate Change Mitigation Plan.

Strategy for Adapting to Climate Change on Ireland's Light Rail and National Road Network

Transport Infrastructure Ireland

Strategy for Adapting to Climate Change on Ireland's Light Rail and National Road Network

- **TII'S STRATEGY FOR ADAPTING TO CLIMATE CHANGE**
- **Road**
  - Managing flood events
  - Flood assessment and Protocol
  - Creating a database of flood events
  - Implementing mitigation measures
  - Coordination with relevant authorities
  - Prevention
  - Energy and carbon assessment
- **Light rail** – severe weather management plan



How resilient is the network to future extreme weather events? Fluvial, Pluvial Coastal.

How will climate change influence these events?

Can we take account of these changes in future designs and how is this achievable?

Summary 1 - How resilient is the network to future extreme weather events

- Flood hazard data supplied for fluvial, coastal and pluvial extreme outlines
- NRA LiDAR data merged into OSI
- Depths, velocities and hazard grids generated
- Linear metrics for hazard on the road
- Combined with traffic volumes to generate a new 'exposure' measure

How will climate change influence these events

- Short duration events more intense
  - Bigger carrier pipes
- Long term
  - Seasonal changes more pronounced
  - Consider changing design approach
- More frequent storm events
  - Return periods

Can we take account of these changes in future designs and how is this achievable.

- Into Design Standards only if specific factors or ranges can be applied to rainfall intensities on a regional scale.
  - Retrofit
  - 20%
- Can adapt a more sustainable SUDS approach by constructing wetlands and using grassed channels.
- Revisit storm design return periods
- Close collaboration between climate modellers and design engineers.

CEDR 2015	Results	TII Actions
WATCH – Water management for road authorities in the face of Climate Change	Methodology for accounting for climate change in rainfall data. Protocols for the implementation of SUDS into designs. Socioeconomic analysis of implementing climate change into designs – cost benefit analysis. Case study on implementation of findings.	New revision of drainage standards and climate change factors. New protocol for the implementation of SUDS. Protocol for cost benefit analysis.

Future Implementation

CEDR 2015	Results	TII Actions
DeTECToR – Decision support tools for embedding climate change thinking on road	Embedding climate change into procurement and design.	Use carbon tool to facilitate carbon savings on road and light rail projects.
MoDBeaR – Mobility Management and Driver Behaviour Research	Awareness of Mobility Management.	Expand on Mobility Management in conjunction with National Transport Agency

Key to implementation

- In house knowledge of water management and NRA's standards and protocols
- Hands on approach to managing CEDR projects – attending workshops – highlighting NRA's requirements
- PEB board with expertise in the specific areas of research
- Translate research findings into policy – assign task to individuals.

Challenges

- SOILS
  - Compaction, erosion, sealing, organic content
- Groundwater Systems
  - Understanding hydrology and hydrogeology in light of Climate Change
- Predicting impacts in karst areas.
- Imbedding CC into designs and procurement.