Rijkswaterstaat
Ministry of Infrastructure and Water Management

Deltares
Enabling Delta Life

UNECE, Athens

Development of a Climate Adaptation Strategy for the InnovA58 highway in the Netherlands

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18 November 2019

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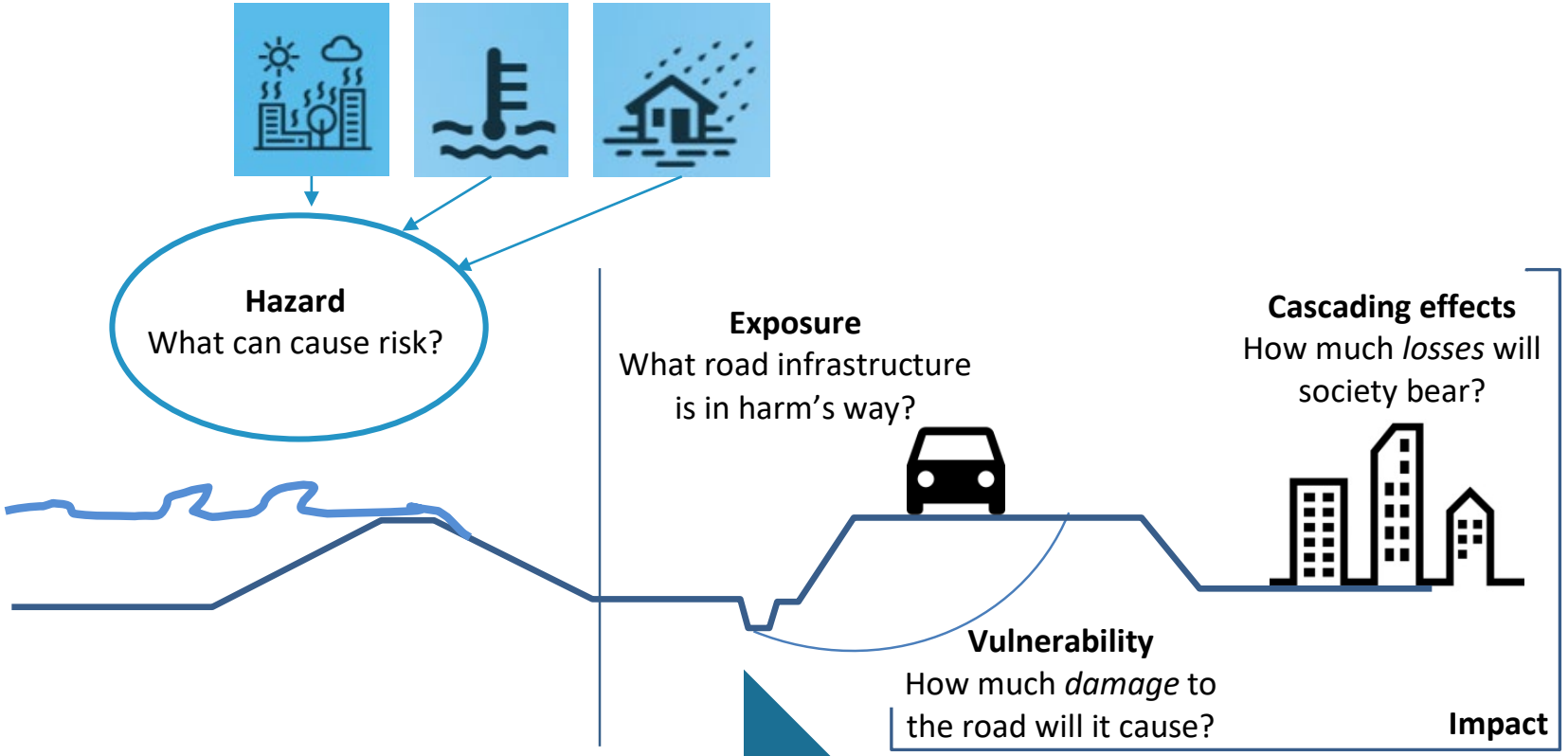
- Case study InnovA58
- Climate resilient road network for The Netherlands
- Multi hazard risk assessment for Albania
- COACHH project

Approach vulnerability assessment and action perspective

Context risk assessments

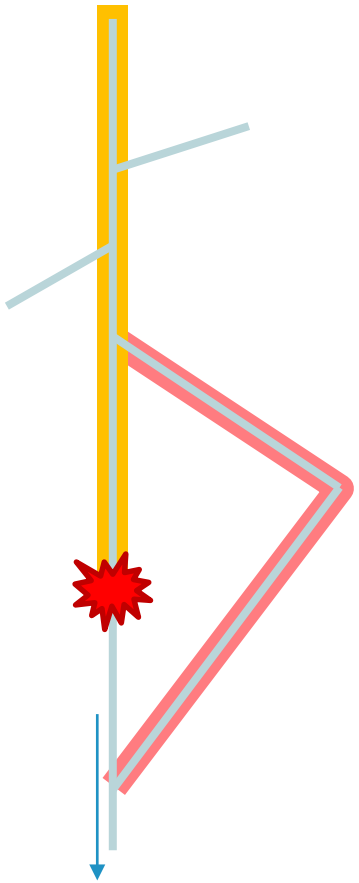


Hazard assessment → Exposure assessment → Vulnerability assessment → Impact assessment → Risk evaluation → Action perspective

Losses – Effects of Disruption

- Vehicle Loss Hours as a result of traffic jams on segment
- Vehicles Loss Hours because of alternative routes
- Damage to road assets (repair costs)
- \

AED = repair costs + economic losses



Cost of increased travel time

+

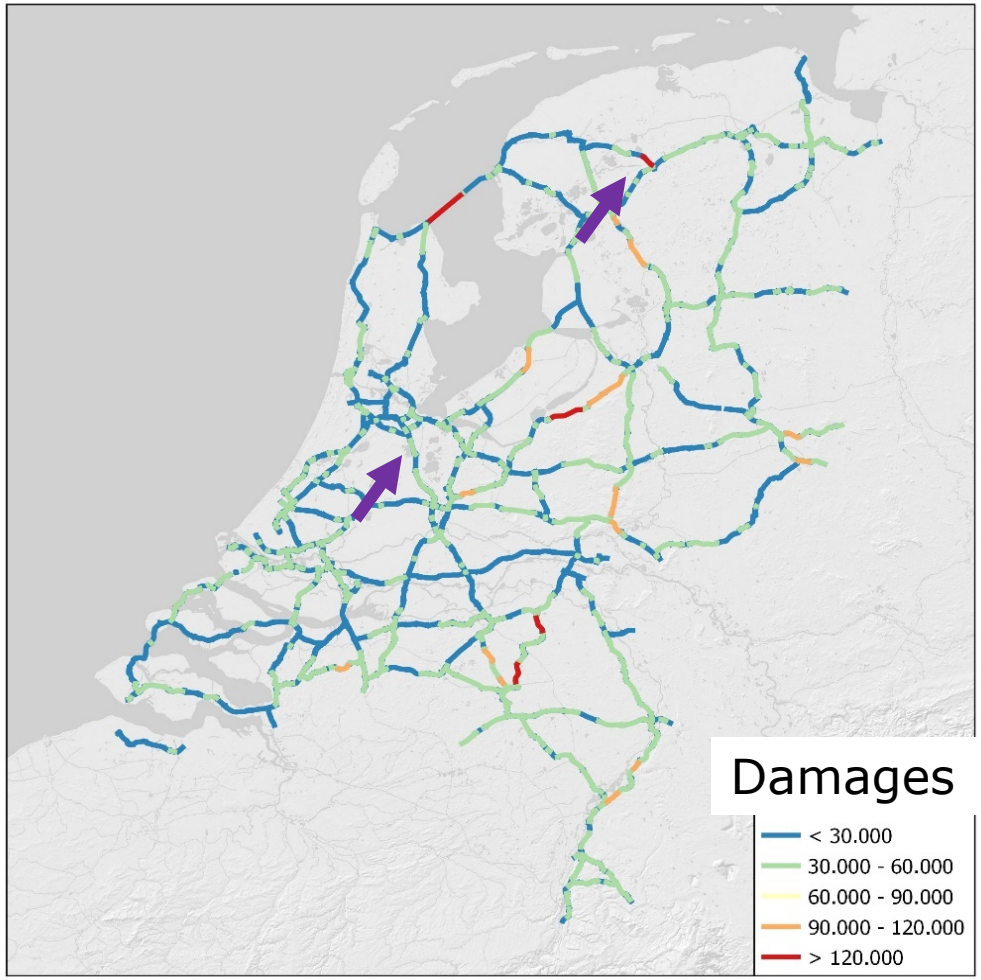
Cost of increased travel distance

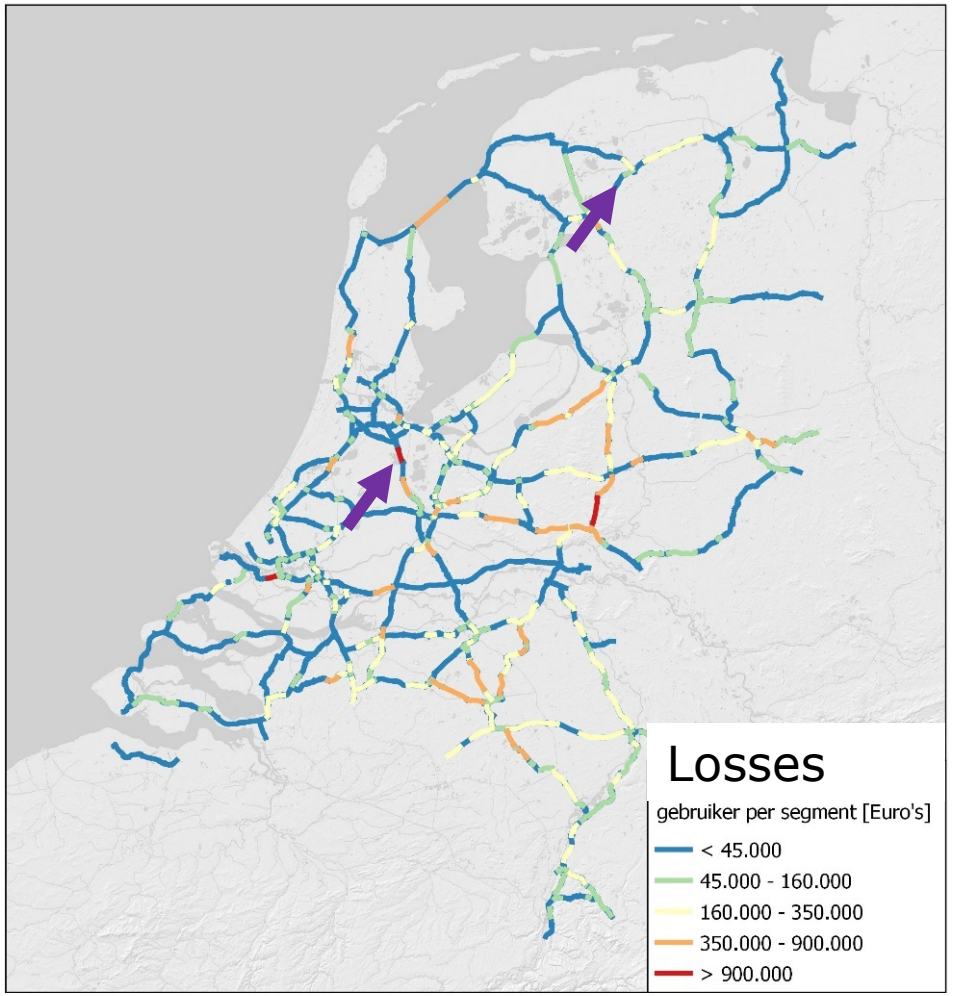
x

Traffic intensity

Total losses

Example for erosion and instability of embankments

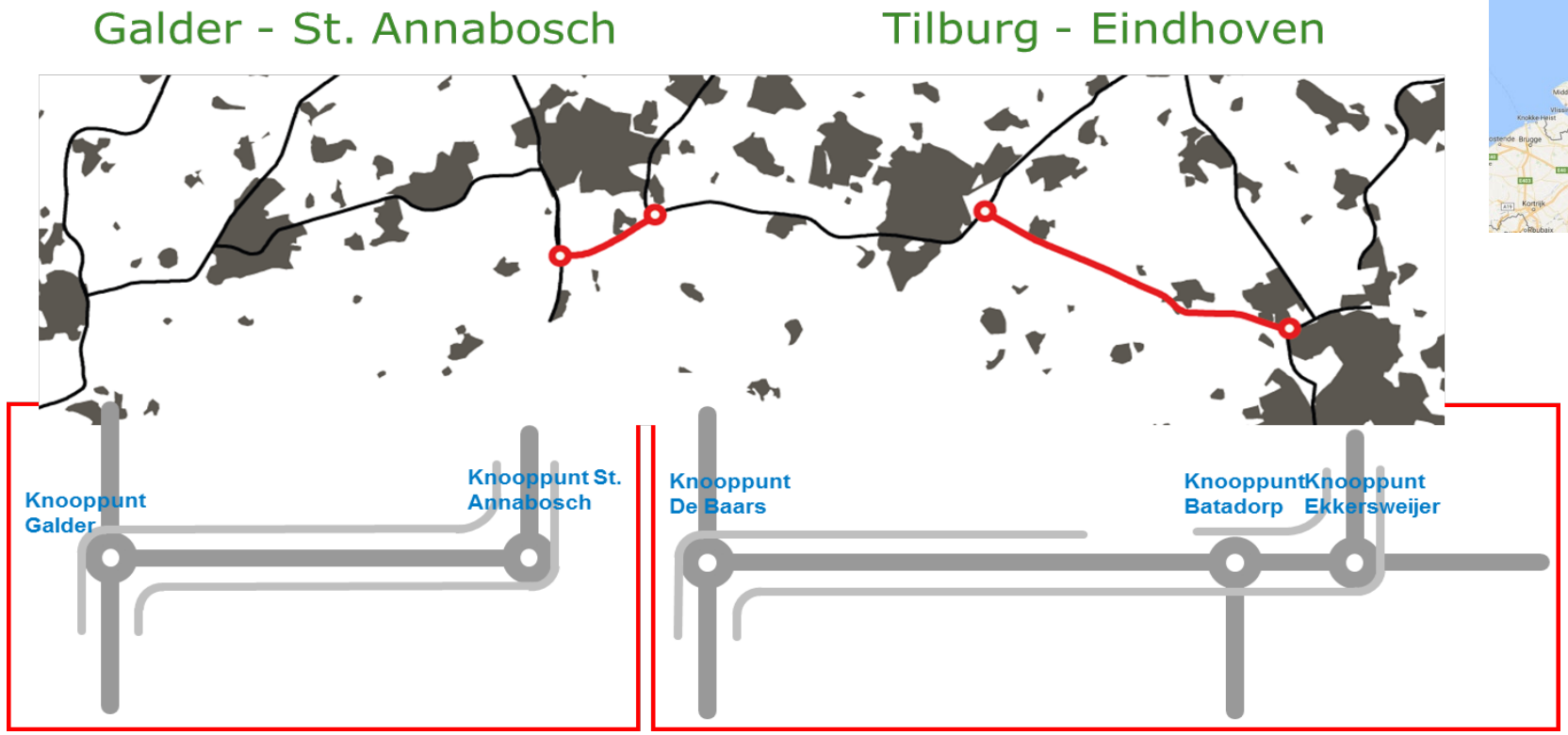




Case study InnovA58

Climate Risk Assessment of A58 highway

The InnovA58 project

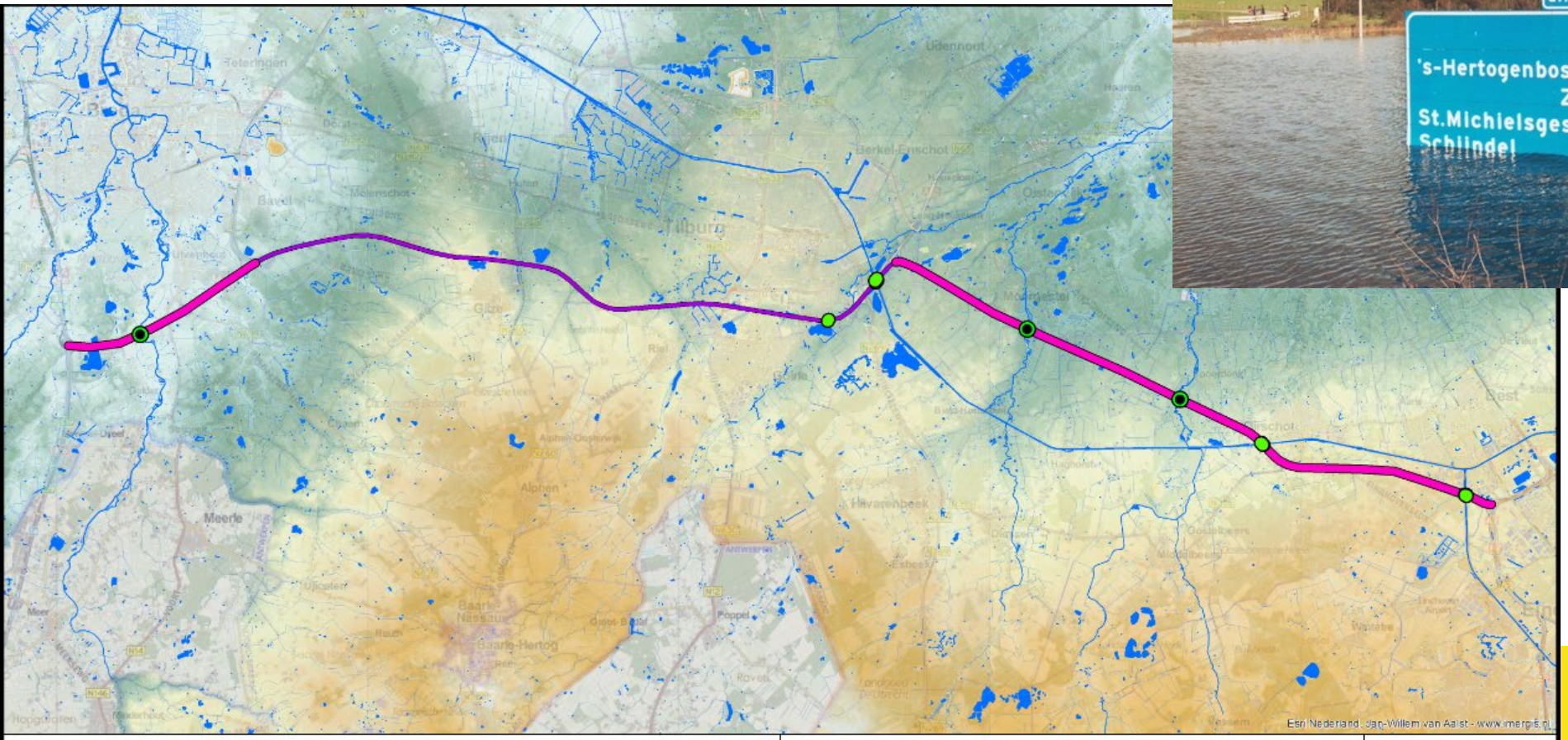


Top risks identified

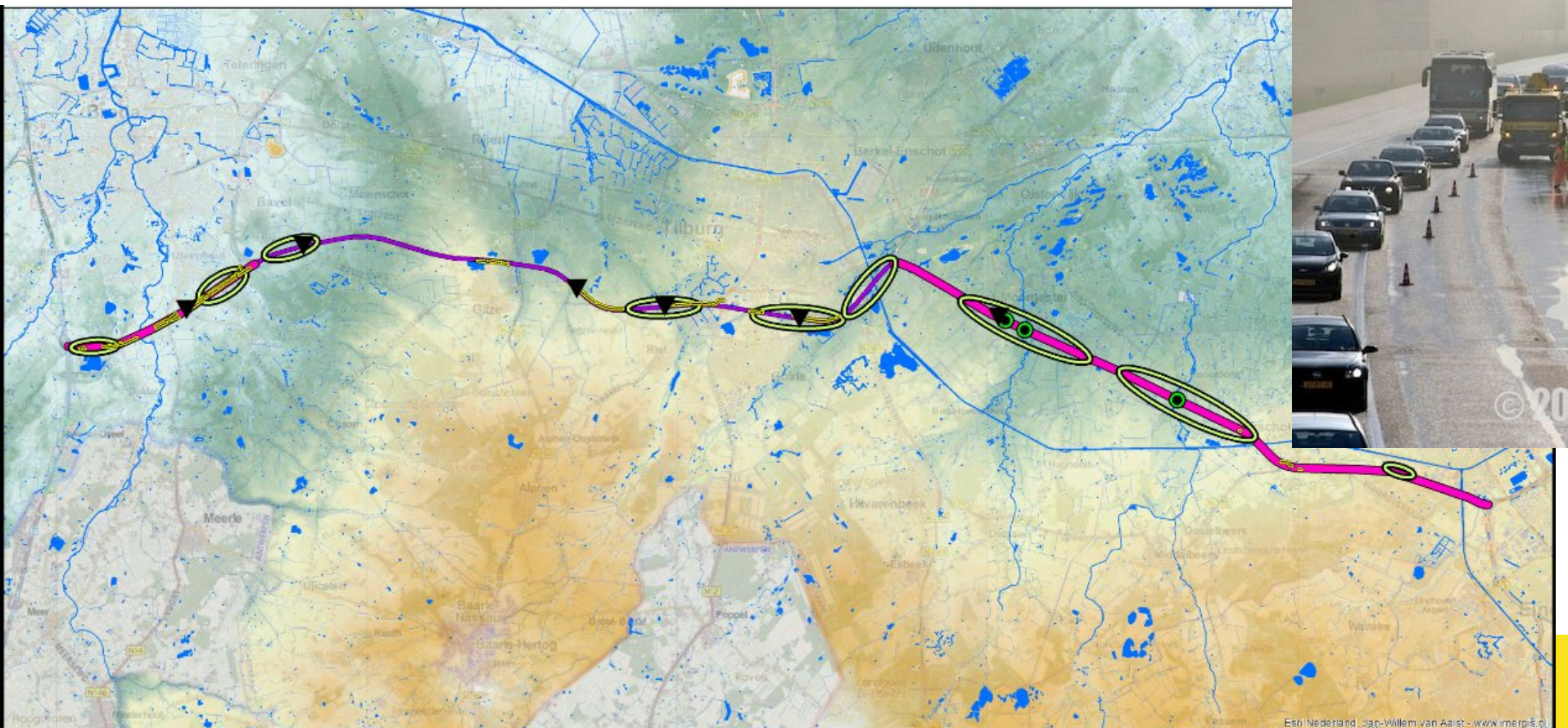
- Flooding (Waterways)
- Flooding (Rainfall)
- Erosion of embankments
- Collapse embankment
- Landslide of embankment
- Loss of visibility
- Loss of skid resistance

1	Flooding of infrastructure as a result of inundation of water systems (streams and rivers)
2	Flooding of infrastructure as a result of heavy rainfall (surface runoff, increase in groundwater level, puddle forming)
4	Erosion of embankments/foundations due to inadequate capacity of waterway structures (e.g. drainage culverts and bridges)
5	Erosion/loss of bearing capacity in the carriageway sub-base due to prolonged water alongside the road
6	Landslide/road subsidence of embankment in periods of extreme precipitation
16	Loss of driving safety due to restricted visibility during snow or showers, including spray
18	Loss of driving safety due to reduction in skid resistance on damp road surface after a long dry period

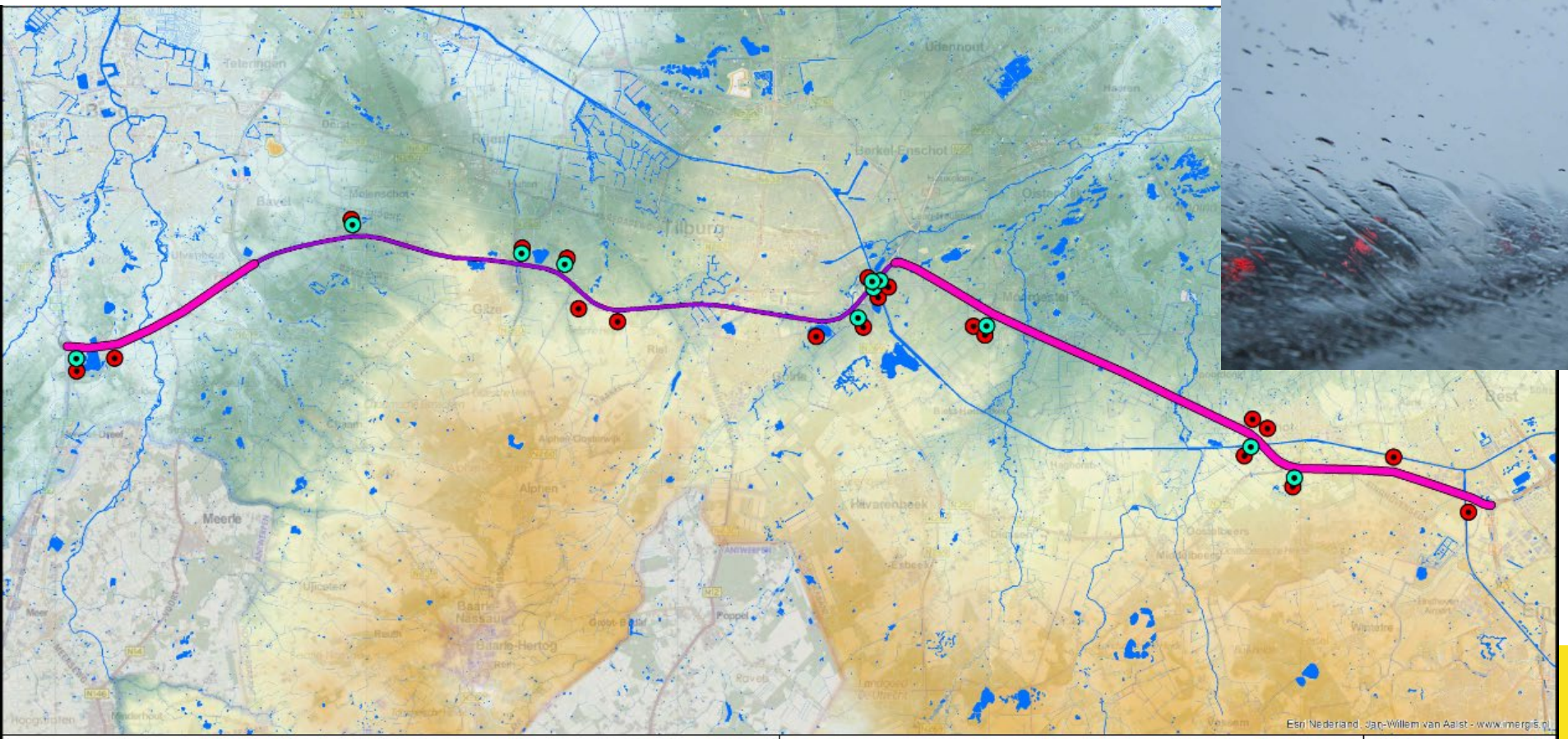
Floods from waterways



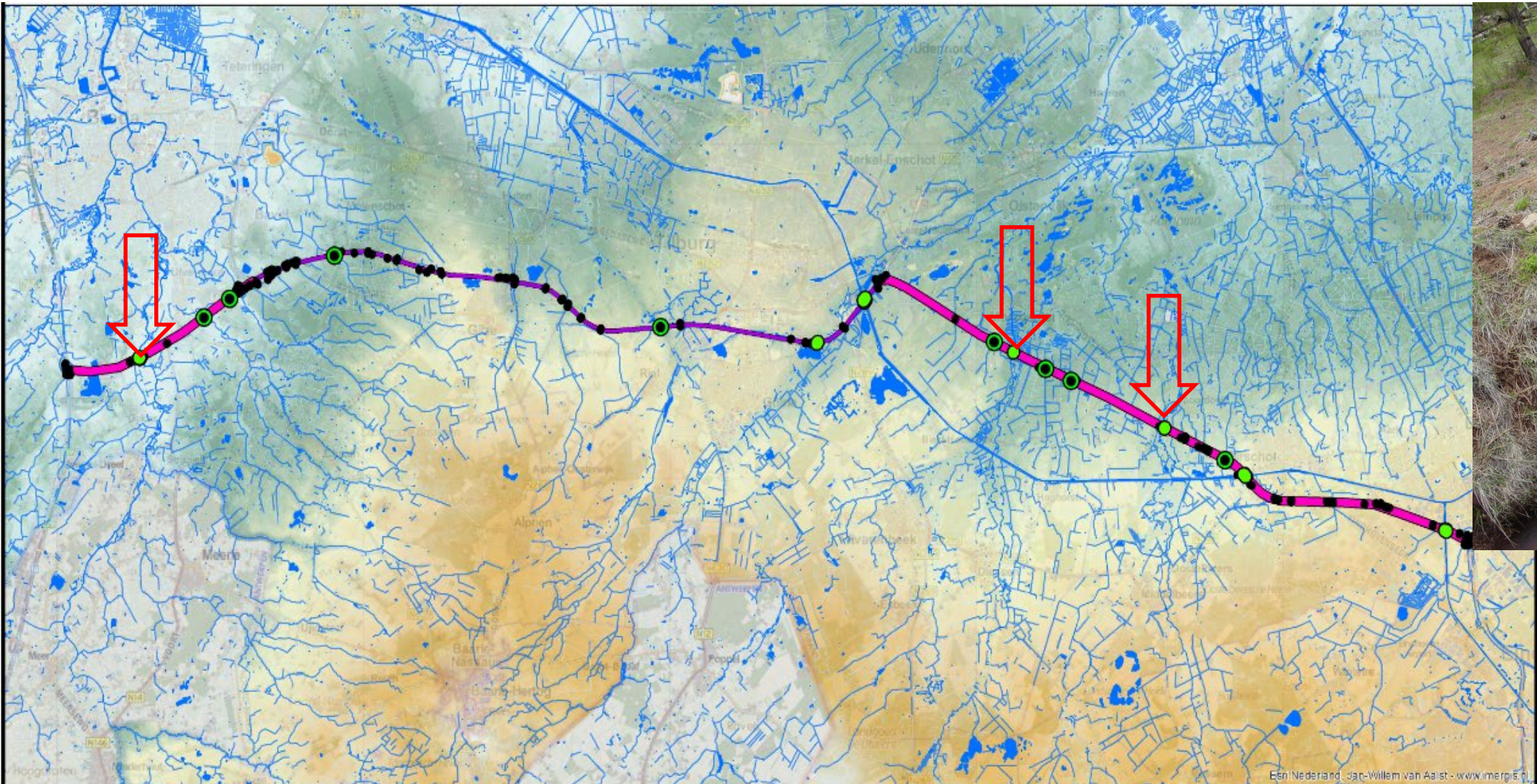
Flooding of road surface due to pluvial flooding



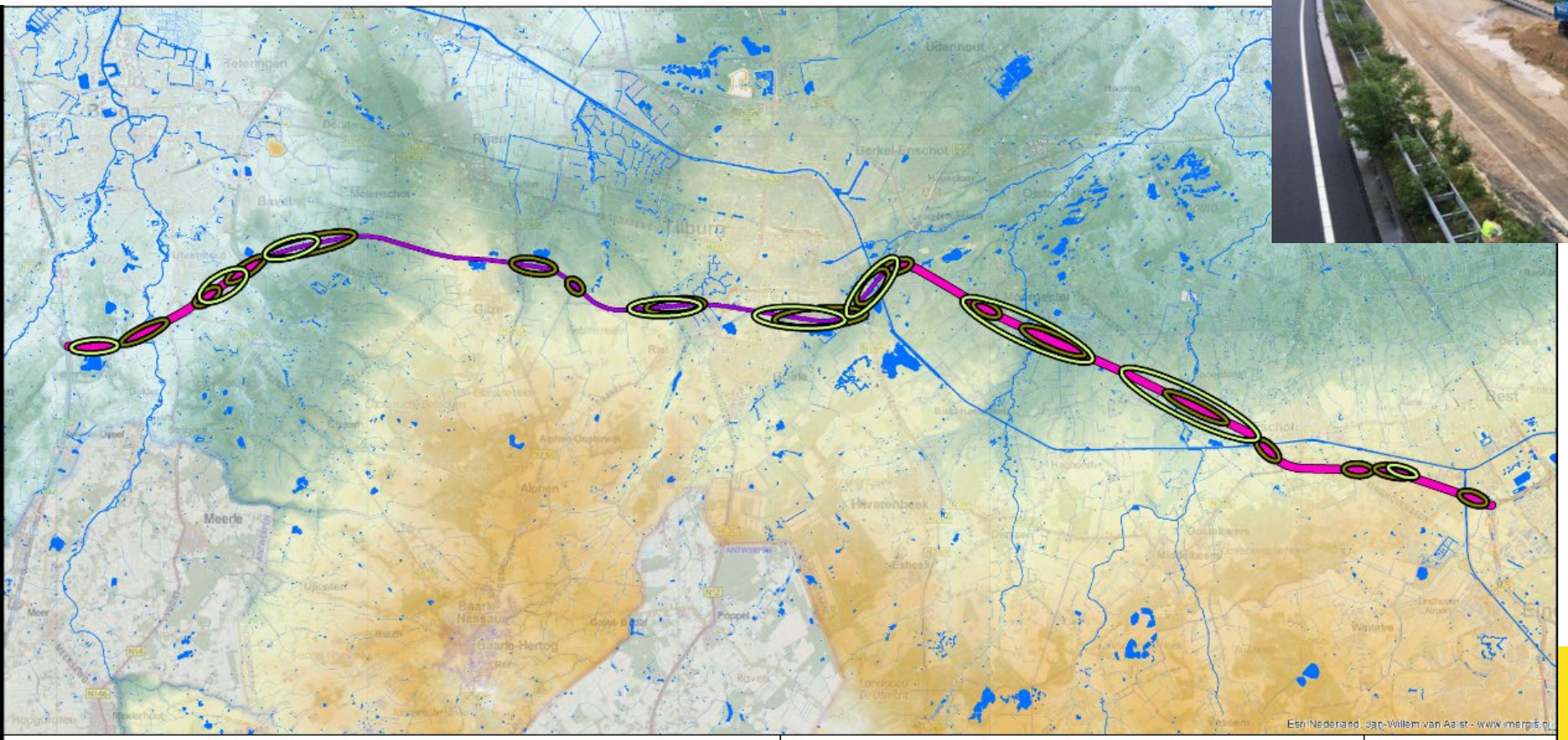
Loss of driving ability due to snowfall & heavy rain



Overloading of hydraulic systems crossing the road



Weakening of the road embankment



Identification of measures

- Longlist of measures
- Effect of measures
- Costs of measures
- Cost Effectiveness Analysis (CEA) of measures
- Development intervention strategy

Selection of measures based on weighted scores							Packages of measures						
						€	1	2	4	5	6	16	18
		Weighted score	CEA (low)	CEA (high)	€k (low)	€k (high)	Flooding of infrastructure as a result of inundation of water systems (streams and rivers)	Flooding of infrastructure as a result of heavy rainfall (surface runoff, increase in groundwater	Erosion of embankments/foundations due to inadequate capacity of	Erosion/loss of bearing capacity in the carriageway sub-base due to prolonged water	Landslide/road subsidence of embankment in periods of extreme precipitation	Loss of driving safety due to restricted visibility during snow or showers, including spray	Loss of driving safety due to reduction in skid resistance on damp road surface after a long
"Loss of traffic safety due to precipitation (#16, 18)"	1	Traffic management	20,5	2,05	1,03	10	20		X				X	X
	3	Education/information (public needs to know that you can't keep driving at 130 km/h)	4,5	0,90	0,45	5	10						X	X
	4	M&M verges & monitoring (NB there is a link to the invitation to tender/contract award here)	9,7	0,13	0,06	75	150						X	X
	6	ITS/SMART mobility (connection of car systems, weather apps with Google Maps, for example)	15,2	5,06	2,53	3	6			X			X	X
	9	More camber (variation on #2)	9,0	9,00	0,00	1	10000		X				X	X
"Instability of embankments (#1, 4, 5, 6)"	1	Erosion-proof vegetation (wall cladding)	16,5	16,50	16,50	1	1			X		X		
	2	Limit design (slope angle) of embankment	17,5	0,07	0,04	250	500					X		
	4	Maintenance of water courses (extra)	8,2	0,08	0,04	100	200	X		X		X	X	
	8	Upstream wadis	16,5	0,17	0,08	100	200	X		X	X	X		
	10	Disasters/recovery plans based on accurate information (monitor/know assets)	7,0	0,14	0,07	50	100	X		X	X		X	
	14	Marker poles to indicate road location in case of flooding	9,0	9,00	1,80	1	5			X			X	
"Water from one side of the road to the other" "stream passages & drainage culverts" (#1, 4, A)	1a	Increase capacity of existing BRIDGES (raise height/widen)	25,0	0,01	0,00	1500	10000	X	X	X	X	X		
	1b	Increase capacity of existing DRAINAGE CULVERTS (raise height/widen)	27,0	0,03	0,01	300	2000	X	X	X	X	X		
	2	More robust water system; bridges/drainage culverts in more locations	22,5	0,08	0,01	300	2000	X			X	X		
	3	More robust water system: build water storage (ditches/ponds) in which water falling on the road itself is collected so as to reduce load on streams	22,5	0,23	0,11	100	200	X	X		X	X		
"Pluvial flooding of surrounding area resulting in road flooding, or pluvial flooding of the road itself" (#2)	1	Make sure water can drain/flow away (e.g. at noise barriers)	20,2	0,40	0,20	50	100		X			X	X	
	2	Guarantee flatness of longitudinal profile of the road (possibly in combination with raising level of road)	15,0	3,00	1,50	5	10		X				X	
	3	build water storage alongside road	19,5	0,20	0,10	100	200		X					
	6	Dimension/design intersections to cope with intense precipitation (as these are particularly vulnerable)	17,0	17,00	17,00	1	1		X					
	7	Improve/use traffic management; reduce speed	7,7	0,77	0,38	10	20						X	X
	9	Technical modifications to cars that would make their use in wet conditions safe and possible	12,7	12,67	12,67	1	1		?				X	
	11	No wells but gutters along entire length	13,5	13,50	0,03	1	500	X	X					
	12	Adaptive management and maintenance	20,5	0,41	0,14	50	150	X	X				X	
	17	Traffic warning systems (cf #7)	16,0	0,80	0,80	20	20						X	X
"Underpasses fill up from surrounding	1	Traffic management (closure)	9,5	0,10	0,10	100	100							
	3	M&M pump systems + capacity	16,0	0,64	0,32	25	50							X
	5	Water storage in surrounding area in order (in relation to the area being (potentially) drained in underpass)	27,0	27,00	27,00	1	1							X
		Score per package of measures per top risk						**163**	**190**	**124**	**121**	**176**	**155**	**105**

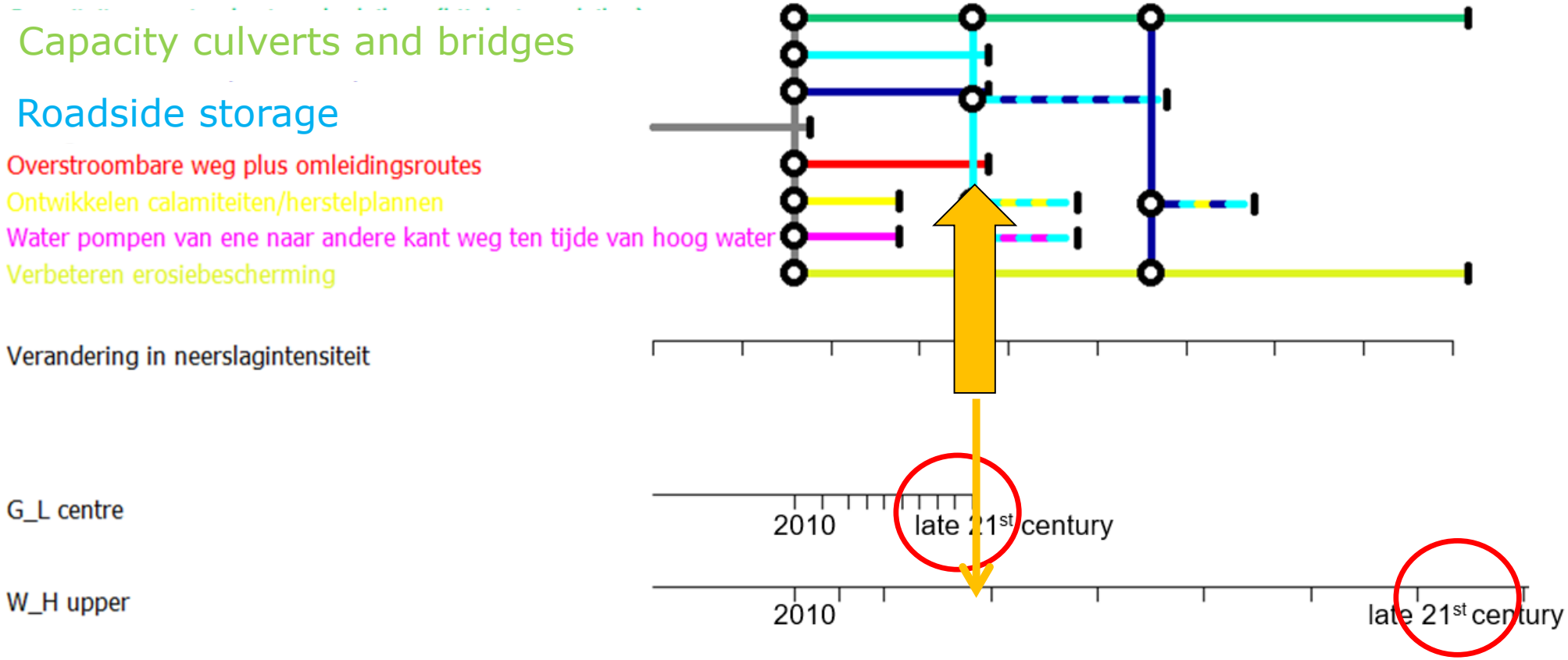
Selection of Cost Effective Measures into Intervention Strategy

Selection of measures based on weighted scores								Packages of measures						
						€		1		4	5	6	16	18
		Weighted score	CEA (low)	CEA (high)	€k (low)	€k (high)		Flooding of infrastructure as a result of inundation of water systems (streams and rivers)	Flooding of infrastructure as a result of heavy rainfall (surface runoff, increase in groundwater	Erosion of embankments/foundations due to inadequate capacity of	Erosion/loss of bearing capacity in the carriageway sub-base due to prolonged water	Landslide/road subsidence of embankment in periods of extreme precipitation	Loss of driving safety due to restricted visibility during snow or showers, including spray	Loss of driving safety due to reduction in skid resistance on damp road surface after a long
"Loss of traffic safety due to precipitation (#16, 18)"	1	Traffic management	20,5	2,05	1,03	10	20		X				X	X
	3	Education/information (public needs to know that you can't keep driving at 130 km/h)	4,5	0,90	0,45	5	10						X	X
	4	M&M verges & monitoring (NB there is a link to the invitation to tender/contract award here)	9,7	0,13	0,06	75	150						X	X
	6	ITS/SMART mobility (connection of car systems, weather apps with Google Maps, for example)	15,2	5,06	2,53	3	6			X			X	X
	9	More camber (variation on #2)	9,0	9,00	0,00	1	10000		X				X	X
nbankments (#1,	1	Erosion-proof vegetation (wall cladding)	16,5	16,50	16,50	1	1			X		X		
	2	Limit design (slope angle) of embankment	17,5	0,07	0,04	250	500					X		
	4	Maintenance of water courses (extra)	8,2	0,08	0,04	100	200	X		X		X	X	

CBA of strategies under different climate scenarios

	Breda	Bavel-Tilburg	Tilburg-Eindhoven
Costs of measures	2.0	1.5	4.4
Benefits (2030 low)	2.2	3.9	5.0
Benefits (2030 high)	3.0	5.1	5.7
Balance (2030 low)	0.2	2.4	0.6
Balance (2030 high)	0.8	3.7	1.3

Adaptation pathway (timing of interventions)



Action perspective

Current works for A58

- Increased capacity 4-lane → 6-lane

Climate adaptation

- **Works with long life span**
  - Capacity increase for bridges and culverts
  - Slope of embankment
  - Water retention
- **Works that can be implemented at later stage**
  - Permeable road surface
  - Inclination of road surface

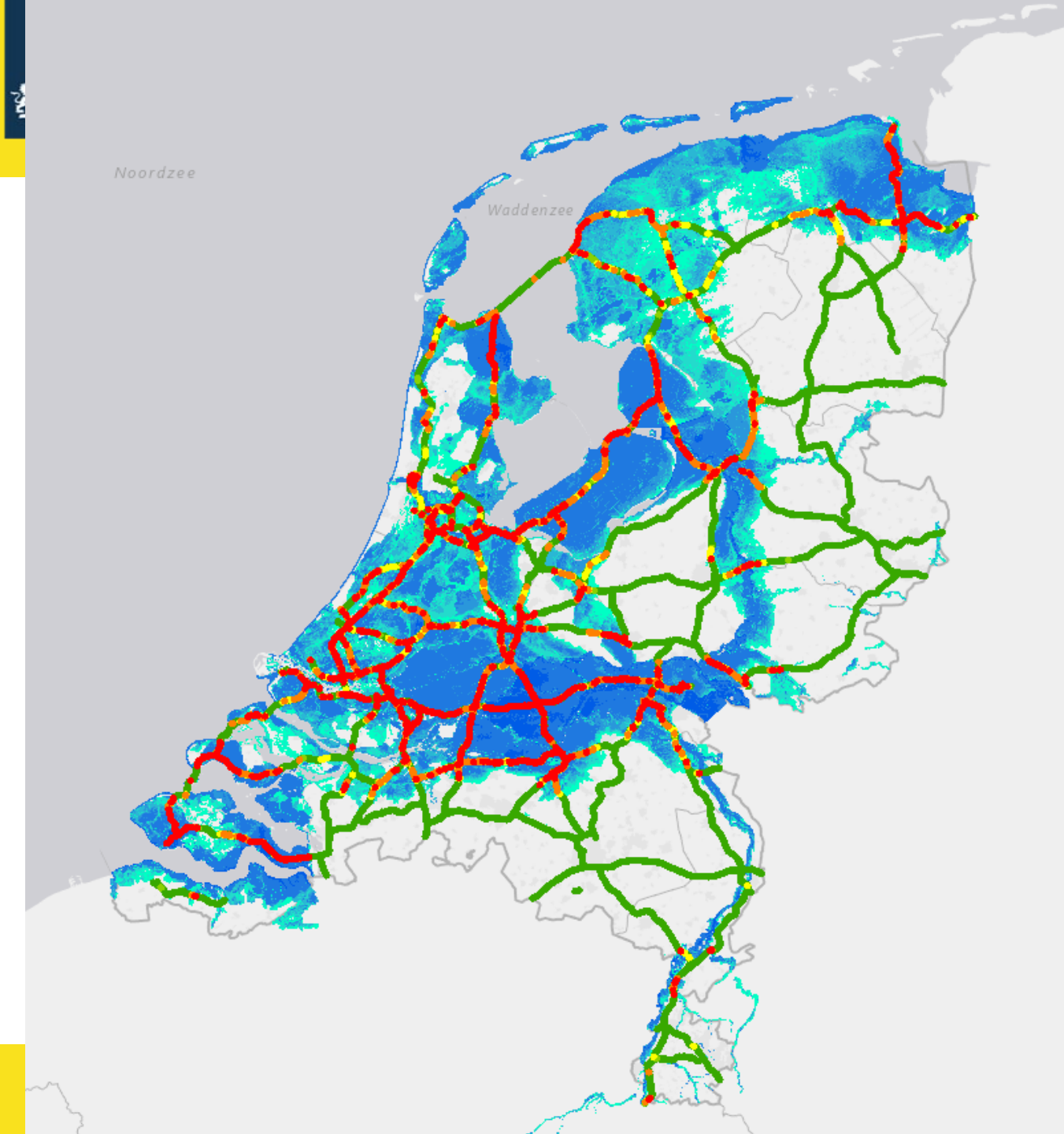
Climate Resilient Road Network in The Netherlands

Objective

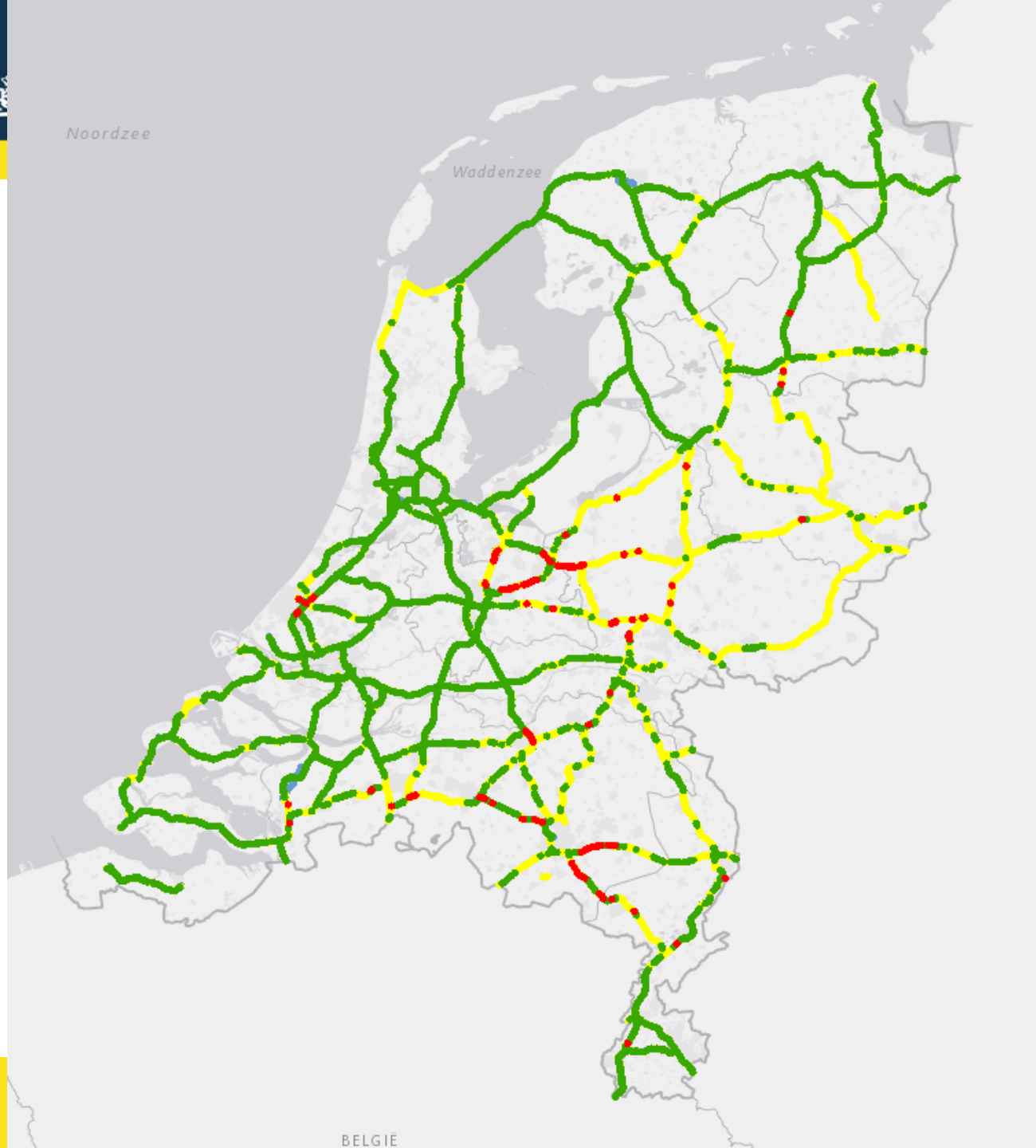
Assess the vulnerability of the primary road network of The Netherlands to different climate related hazards and climate change

Pluvial Floods

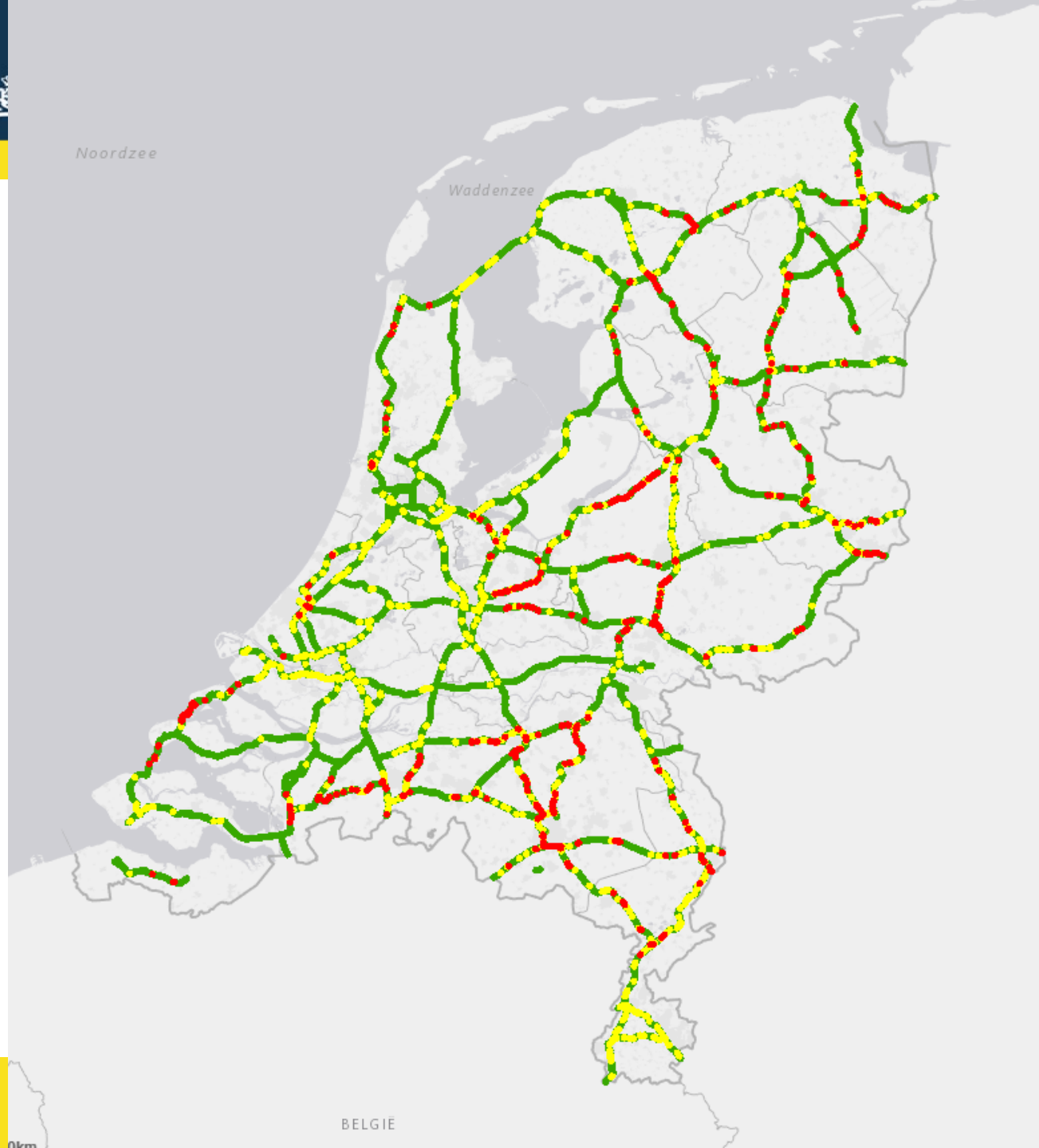
Floods



Roadside Fires (Drought)



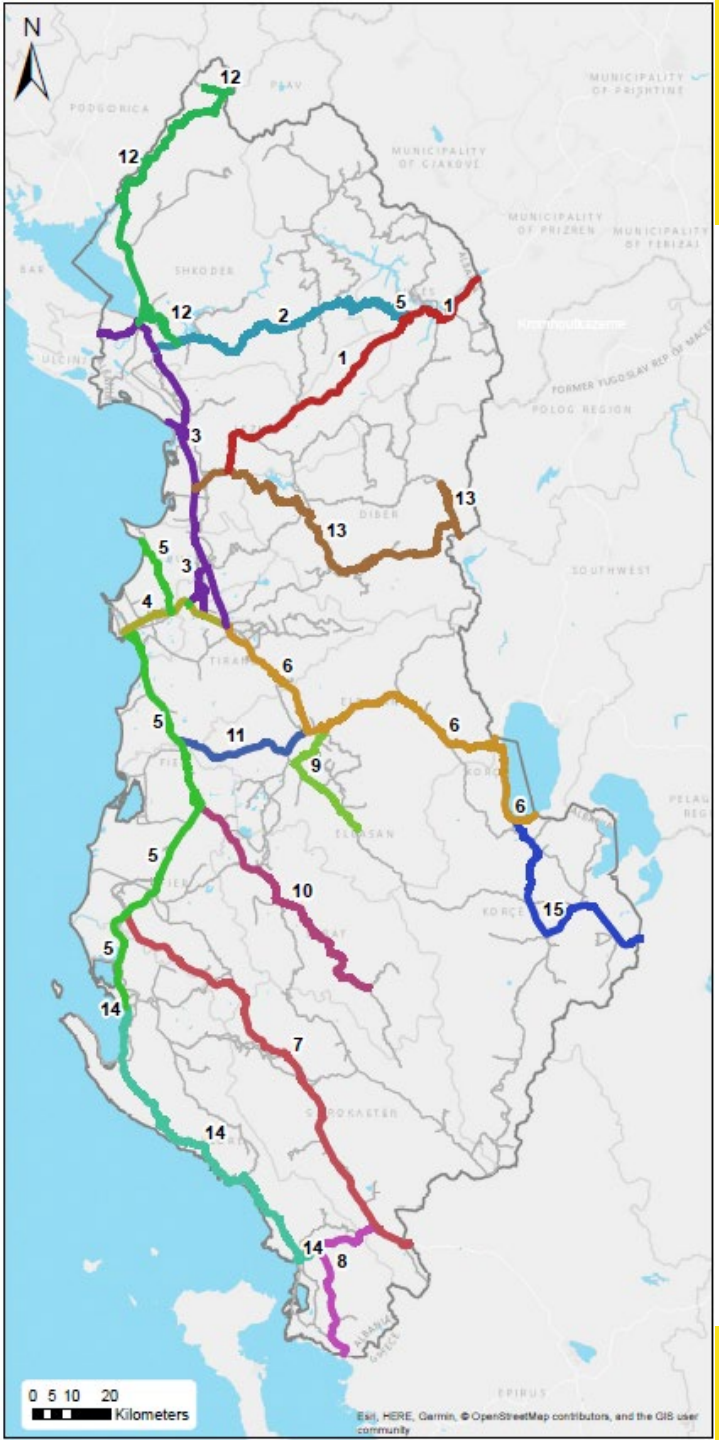
Unstable embankments



Follow up work

- Impact assessment
- Risk assessment and risk dialoque
- Action perspective

Multi Hazard Analysis of the Road Network in Albania



Goal & scope of project

Inform the prioritisation of future climate and seismic resilient investments in primary road assets (in Albania)

Hazards

- Earthquakes
- Landslides
- Floods

Approach – Risk analysis and action planning

Risk analysis per hazard

- Hazard mapping (example; floods)
- Risk analysis → Annual Expected Damages (AED)

Action planning per hazard

- Prioritization of locations
  - Criticality
  - Cost effectiveness analysis
  - B/C ratio

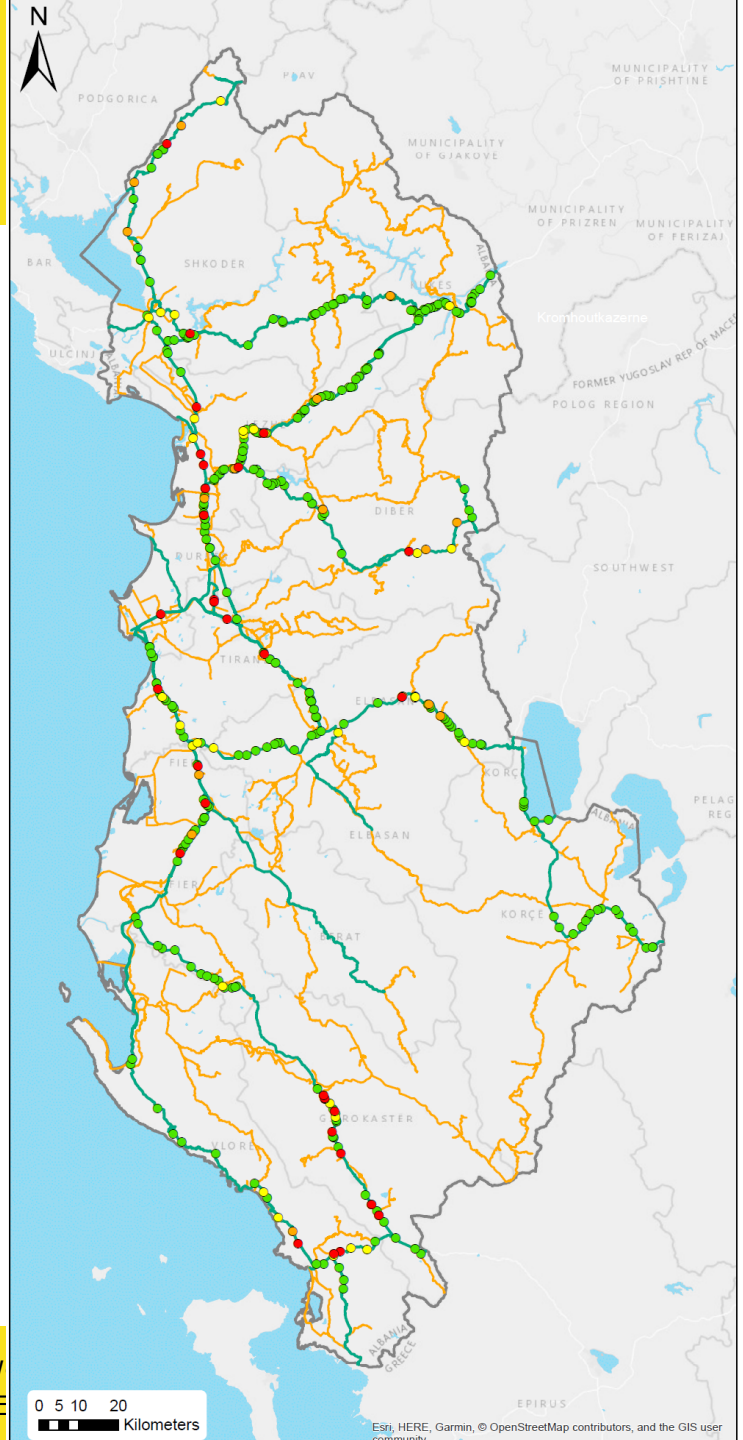
Risk map: Floods

- **Vulnerability**

- Dots indicate culvert and bridge failures (High, Low)

- Based on:
  - Modelled discharges
  - Design capacities

- Interventions on red locations ~ 20 % of assets



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Climate resilient road assets in Alb

This map shows the road network Albania and the Damages from plu floods to bridges and culverts und climate scenario REFERENCE

Date:	10-12-2018
Projectnr:	11200889
Mapcode:	5p2p1v001
Authors:	Mark Hegnauer Ferdinand Diermans Mark de Bel Bujar Drishti

Legend

- Albania country border
- Primary road network
- Secondary road network

Damages from pluvial floods to bridges and culverts
Climate scenario REFERENCE

- No damages
- Small damages
- Medium damages
- Large damages

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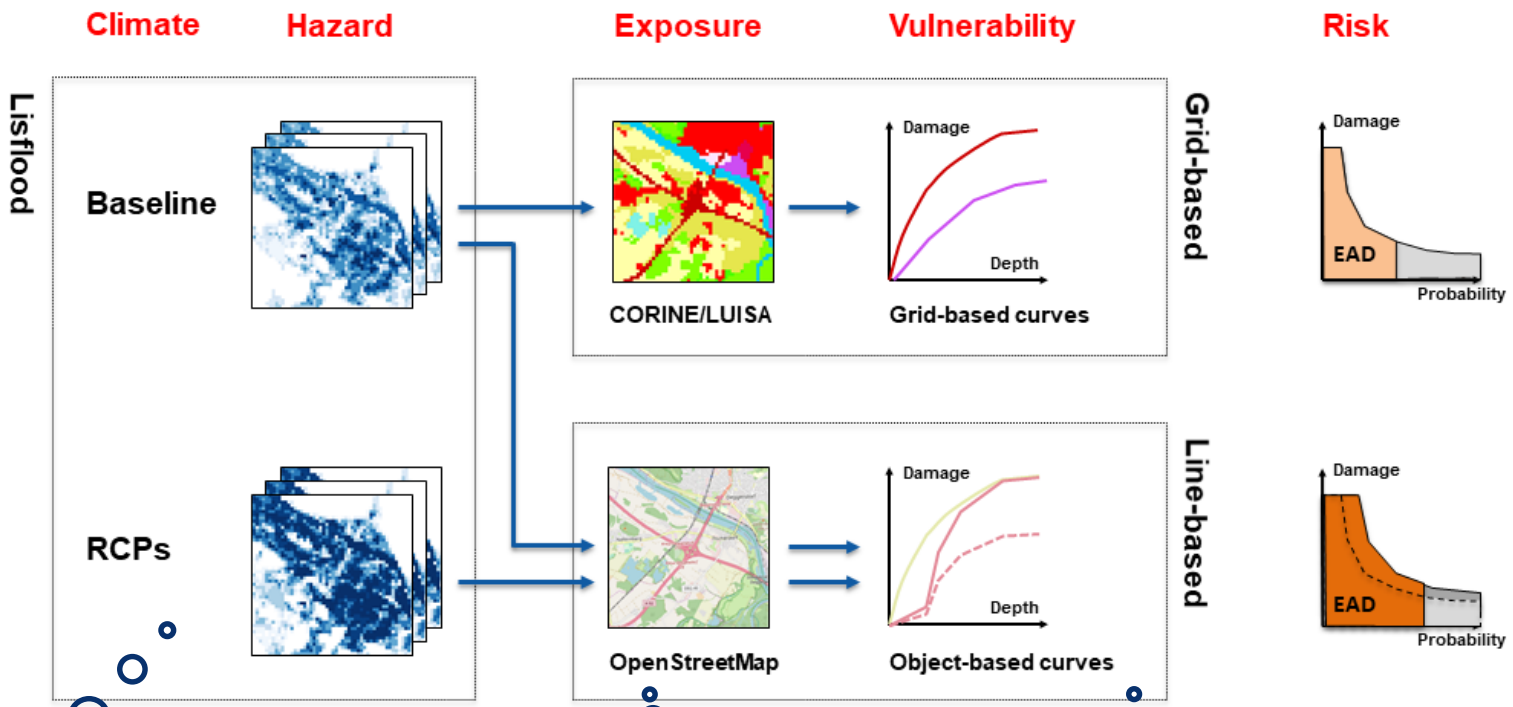
Action plan

!	significant damages
✓	Positive B/C ratio
✓	Positive B/C ratio under certain conditions
✗	Negative B/C ratio

Corridor	Length (km)	AED (€/km) ('000)	Criticality	Floods		Land slides	
				Damage	Intervention	Damage	Intervention
01 Milot - Morine New	104	3,3	42			!	✗
02 Shkoder - Puke - Kolsh	126	1,0	24	!	✓	!	✗
03 Milot - Shkoder - Muriqan	127	12,8	37	!			
04 Tirana - Durres	32	59,1	53	!	✓		
05 Durres - Vlore	152	69,0	52	!	✓	!	✓
06 Tirana - Elbasan - Pogradec	139	24,9	42	!	✓	!	✓
07 Fier - Gjirokaster - Kakavi	128	10,6	37	!	✓		
08 Gjirokaster - Sarande - Ksamil	58	1,4	39	!			
09 Elbasan - Gramsh	41	0,7	26				
10 Lushnje - Berat - Çorovode	86	4,1	24	!	✓		
11 Rrogozhine - Elbasan	40	0,9	37				
12 Shkoder - Hani i Hotit - Vermos	125	2,3	40	!	✓		
13 Milot - Peshkopi	136	5,3	30	!	✓	!	✗
14 Vlore - Sarande	131	2,4	39	!	✓	!	✗
15 Pogradec - Korce - Kapshtice	69	1,0	45				


COACCH
CO-DESIGNING THE ASSESSMENT OF CLIMATE CHANGE COSTS

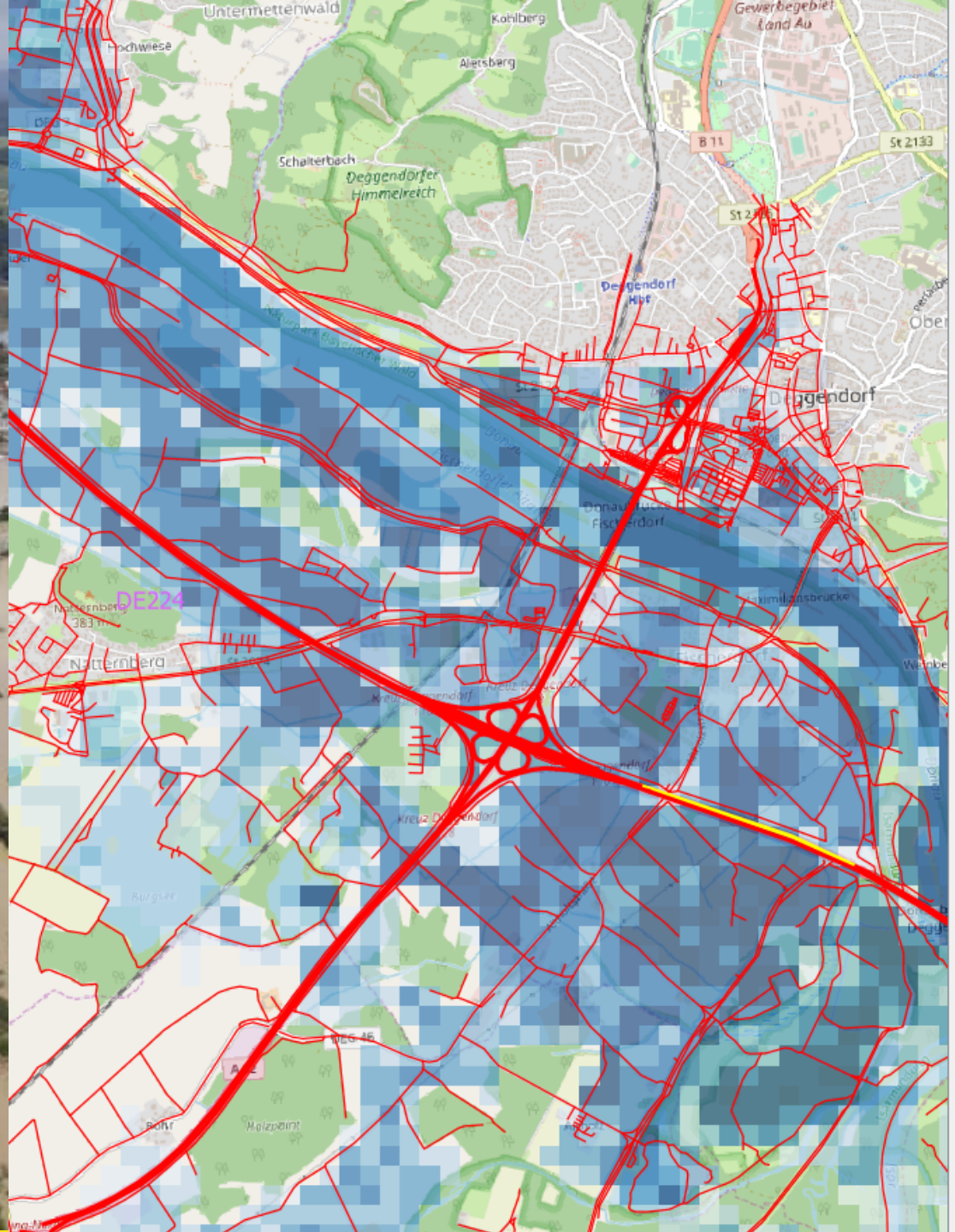
Method: new line-based flood risk assessment



High resolution flood modelling (100*100 m²)

High-resolution exposure data

Co-designed damage curves



Identify Results

Feature

- DE224
  - osm_id
    - (Derived)
    - (Actions)
    - field_1
    - osm_id
    - infra_type
    - lanes
    - bridge
    - length
    - road_type
    - length_rp10
    - val_rp10
    - length_rp20
    - val_rp20
    - length_rp50
    - val_rp50
    - length_rp100
    - val_rp100
    - length_rp200
    - val_rp200
    - length_rp500
    - val_rp500
    - NUTS-3
    - NUTS-2
    - NUTS-1
    - NUTS-0

Mode: Current layer

View: Tree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Helsinki
Hamina Kotka
Tallinn
Oslo
Örebro
Stockholm
Ventspils
Riga
Gothenburg
Klaipeda
Glasgow
Edinburgh
Belfast
Copenhagen
Malmö
Trelleborg
Vilnius
Kaunas
Gdynia/Gdansk
Dublin
Manchester
Liverpool
Rostock
Szczecin/Swinoujscie
Bremen
Hamburg
Birmingham
Cork
Amsterdam
Utrecht
Osnabrück
Berlin
Poznan
Warsaw
Felixstowe
Rotterdam
Magdeburg
Frankfurt/Oder
London
Hannover
Zeebrugge
Antwerp
Düsseldorf
Southampton
Dover
Calais
Gent
Cologne
Dresden
Wroclaw
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Cartagena
Limassol
Algeciras
Valletta
TENtec

Thank you

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