Investigation of flooding for a large urban catchment

Lothar Fuchs, Hannover, Germany

Institut für technisch-wissenschaftliche Hydrologie GmbH
HANNOVER | DRESDEN | FLENSBURG | NÜRNBERG

Engelbostler Damm 22
30167 Hannover

Tel.: +49-(0)511-97193-0
Fax: +49-(0)511-97193-77

e-mail: itwh@itwh.de
Internet: www.itwh.de

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Content

- **Background and European Regulations**
- **Hazard Analysis and Risk Assessment**
- **Summary**

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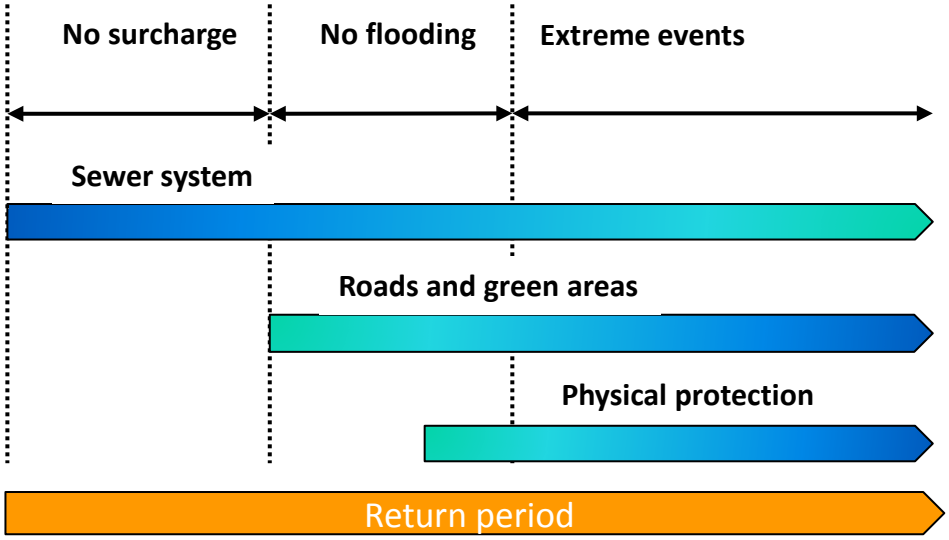
Background and European regulations

- **Climate change**
- **Stepwise procedure to analyze effects of flooding**



after DWA, 2009

Return period	flooding
Rural areas	10
Residential areas	20
City center	
- with check of flooding	30
- without check of flooding	
Subways/underpasses	50

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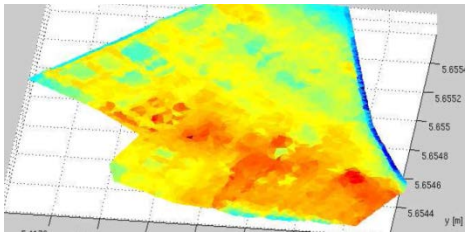
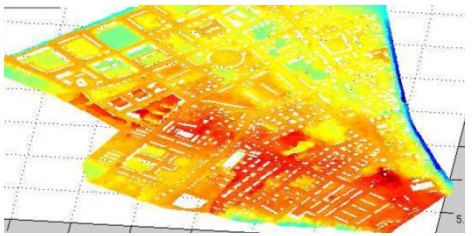
Problems

- **Limited data or lack of data**
- **Data mining expensive (for a large catchment)**
- **Depending on approach**
  - Rough GIS analysis
  - Simple 1-D/2-D approach with rough areal resolution
  - Detailed 1-D/2-D approach with high resolution data

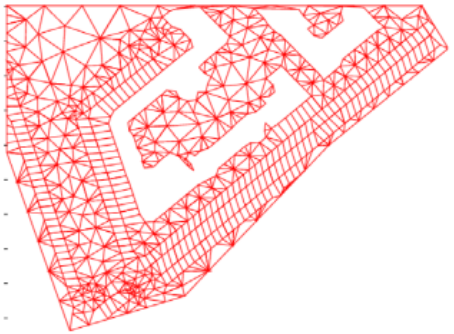
  Computational time and manual effort is a problem





Solution

- **Identification of areas with risk of flooding**
- **Detailed 2-D approach with high resolution data**
- **Software used: itwh HE-2D, ArcGIS-application**



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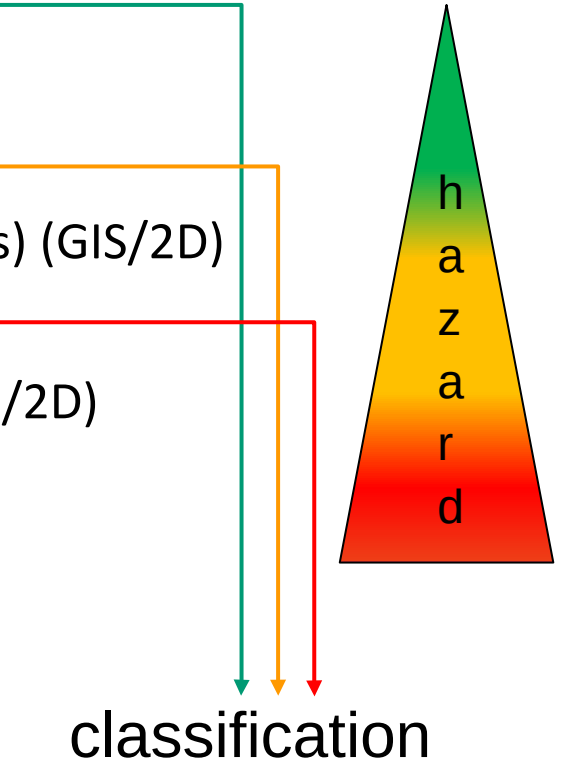
Classification – Definition of areas with risk of flooding

- **Stage1:**
  - Surcharge and test of flooding (1D)
- **Stage 2:**
  - Analysis of flooding (flow paths and flooding areas) (GIS/2D)
- **Stage 3:**
  - Detailed simulation of flooding on the surface (1D/2D)



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Stage 1: Test of flooding

- **Simulation with a "normal" hydrodynamic sewer model**
- **Return period of design storm according to regulations or objective**
- **Classification based on water levels and overflow/flooded volumes**

Hazard classes (GK)	Classification	Reason
0	No hazard	Water level ≤ 2.5 m under ground level
1	Slight hazard	Water level ≤ 1 m under ground level
2	Moderate hazard	Overflow ≤ 5 m³
3	Great hazard	Overflow < 1,000 m³ *)
4	Very great hazard	Overflow ≥ 1,000 m³ *)
*) or assessment in the form of a flood test		

- **Optional: calculation of a key hazard figure**

$$\mathrm{RKZ} = \frac{1}{Lges} * \sum_{1}^{n} (RK_i * L_i)$$

GKZ: Key hazard figure drainage system
L_i: Length of the upstream pipe i in meters
GK_i: Hazard class for position i
L_{ges}: Total length of the pipes considered in meters
n: Number of positions considered

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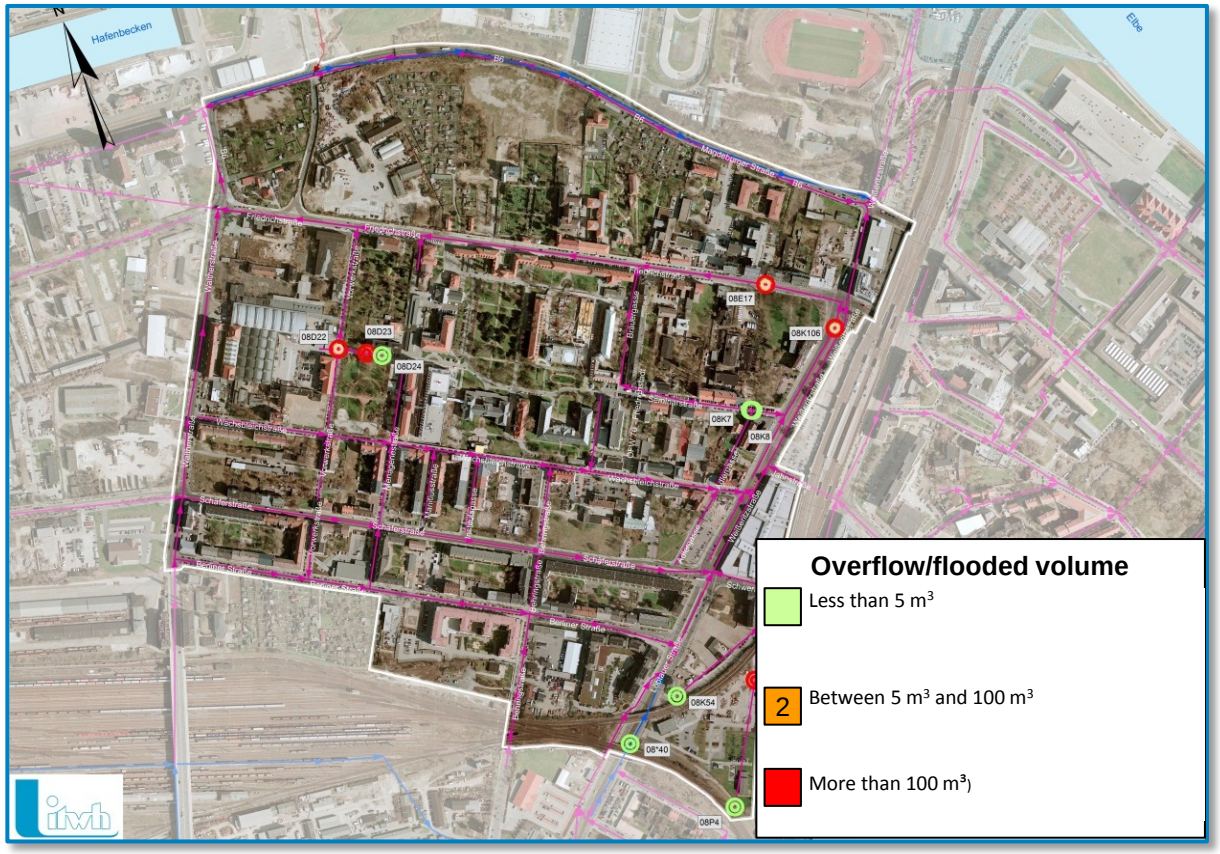
Stage 1: Example results



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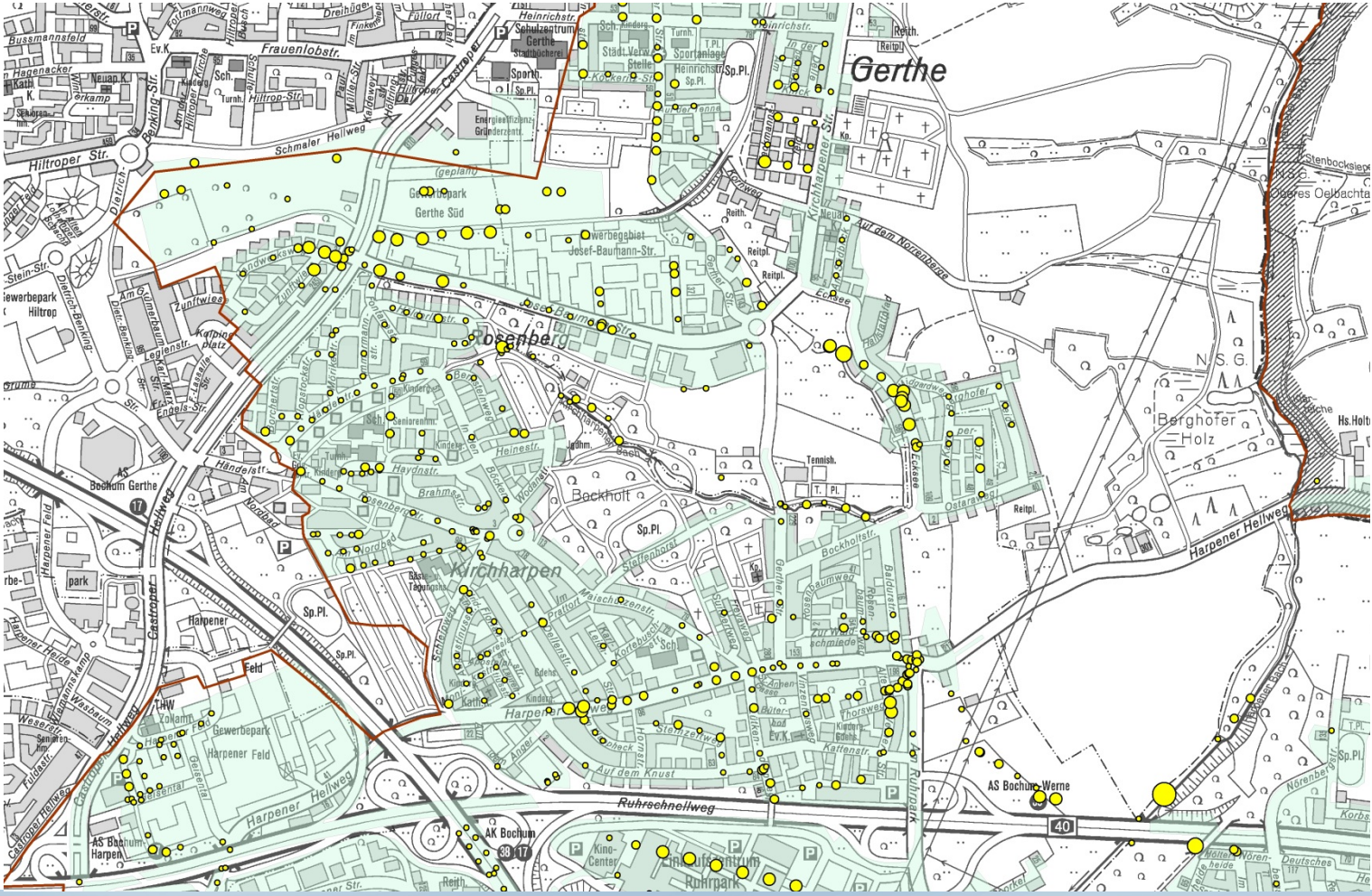
Stage 1: Example results



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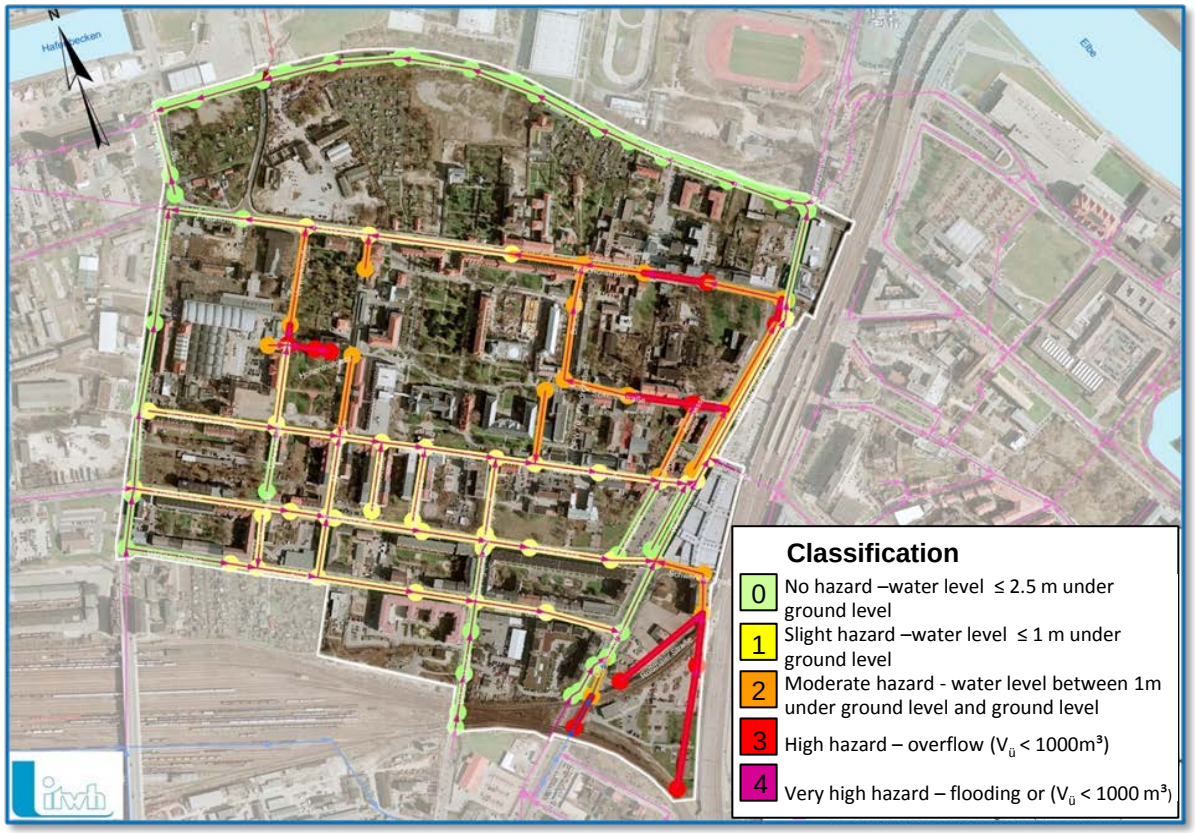
Stage 1: Example results - Classification



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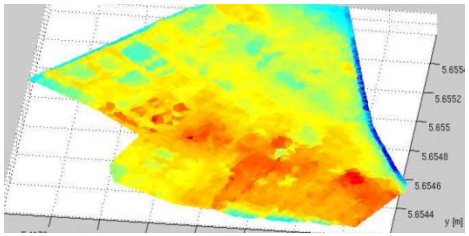
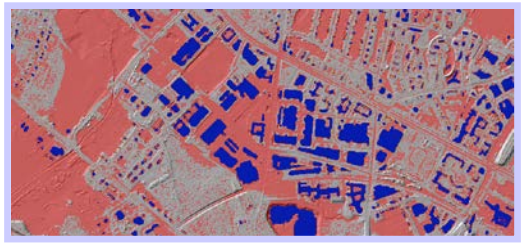
Stage 2: Analysis of flooding (flow paths and flooded areas)



- **Method**
  - GIS or rough 2-D model
- **Necessary data**
  - Results of simulation model (overflow/flooded volumes)
  - Digital terrain model/areal photograph
- **Results**
  - Identification of flow paths and depressions
  - Extended classification
  - Rough quantification of potential damage
  - Identification of areas for detailed simulation



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Stage 2: Example results based on GIS analysis

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Stage 2: Example results based on GIS analysis

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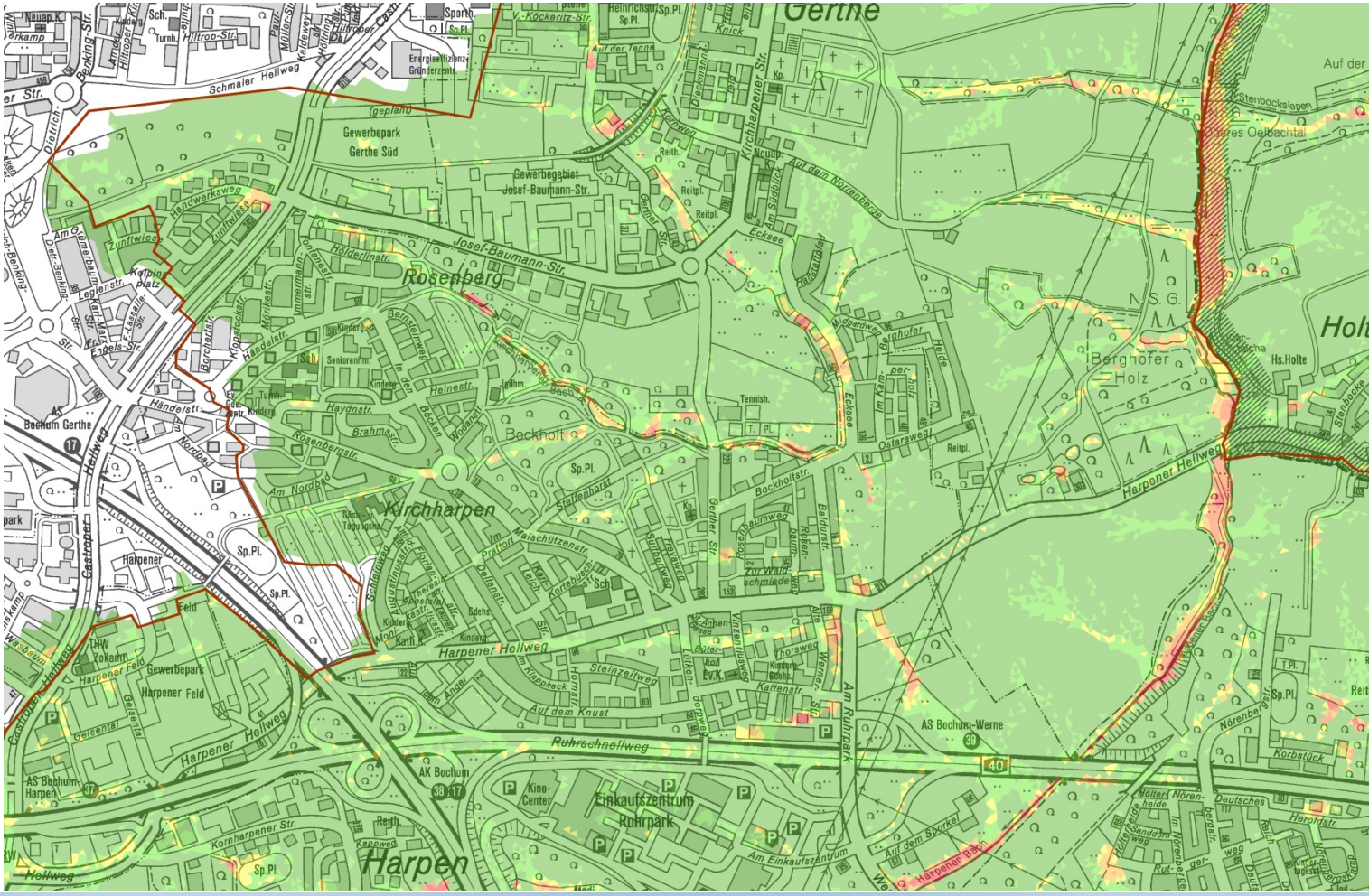
Stage 2: Example results based on rough 2-D simulation



Risk of flooding

Water level	
0 - 0.02	Very low
0.02 - 0.10	low
0.10 - 0.30	moderat
0.30 - 0.60	Slight high
0.60 - 1.0	high
> 1	Very high

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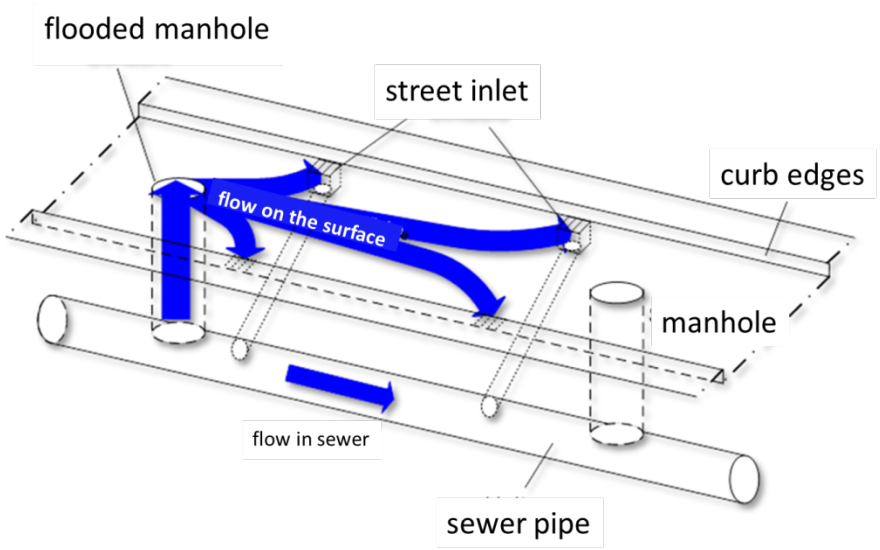
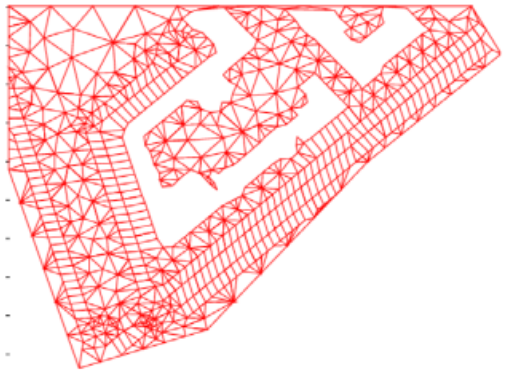
Stage 3: Detailed simulation of flooding

- **Method**
  - Bidirectional coupled (integrated) simulation of flow in sewer system (1-D) and flow on the surface (2-D)





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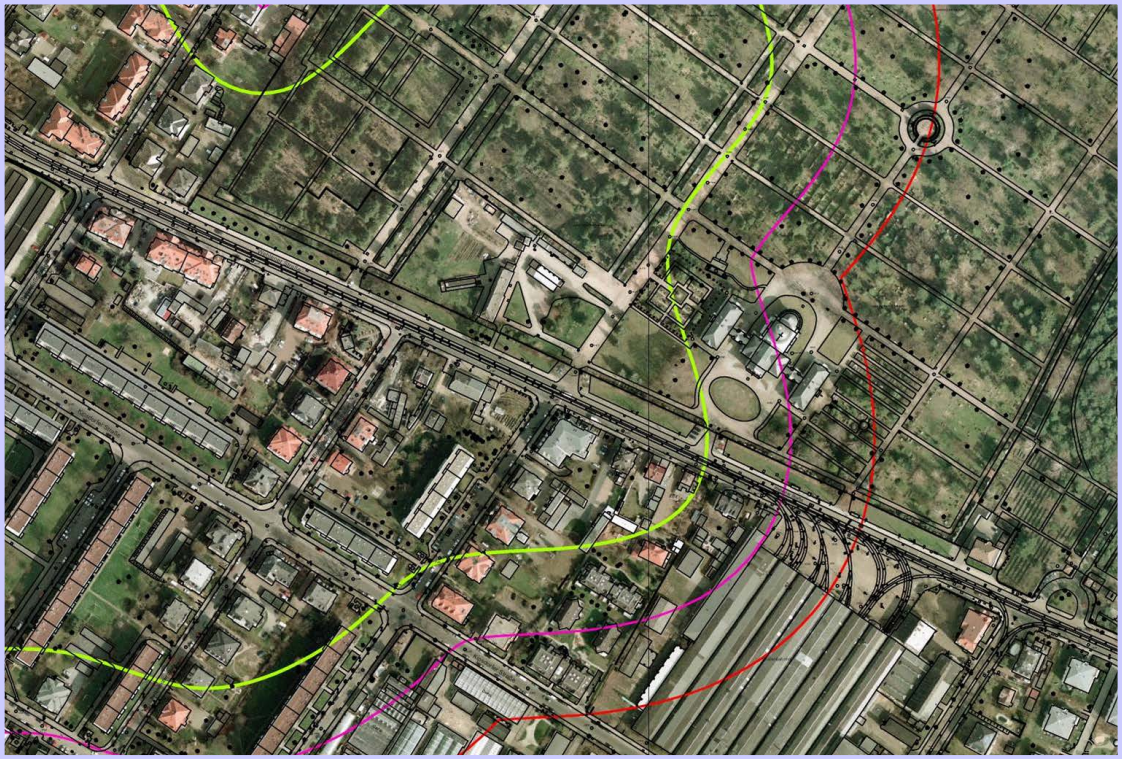
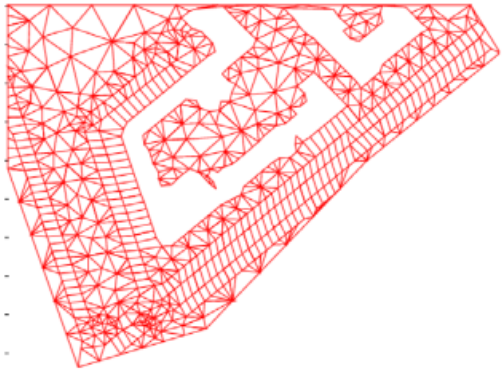
Stage 3: Detailed simulation of flooding

- **Necessary data**
  - Areal photograph – Definition of area for detailed simulation





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Stage 3: Detailed simulation of flooding

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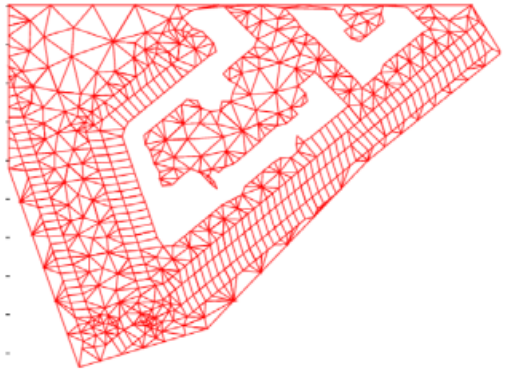

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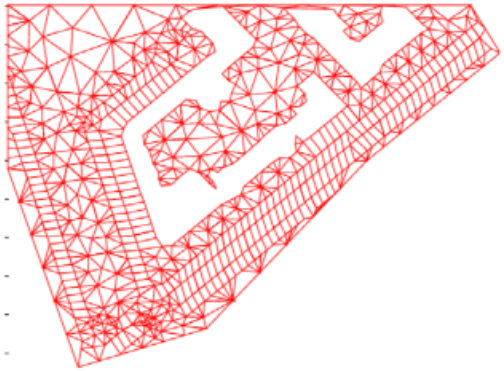
Stage 3: Detailed simulation of flooding

- **Necessary data**
  - Building polygons, street boundaries, type of surface, street inlets



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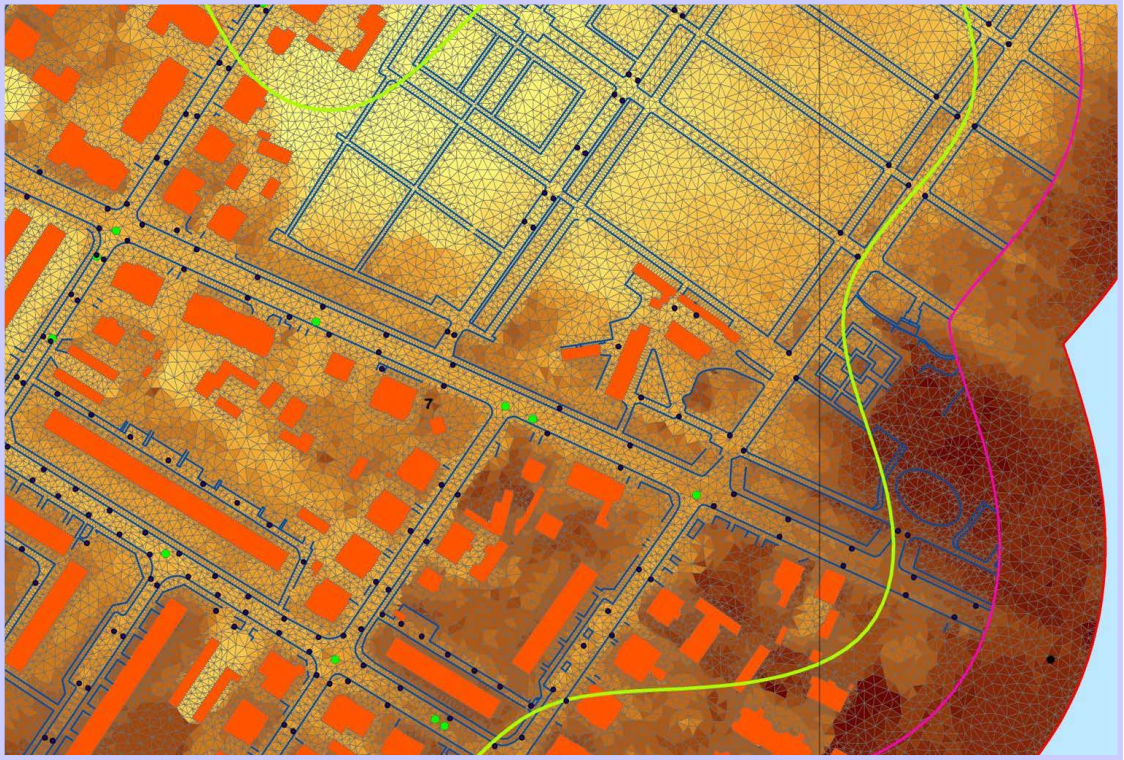
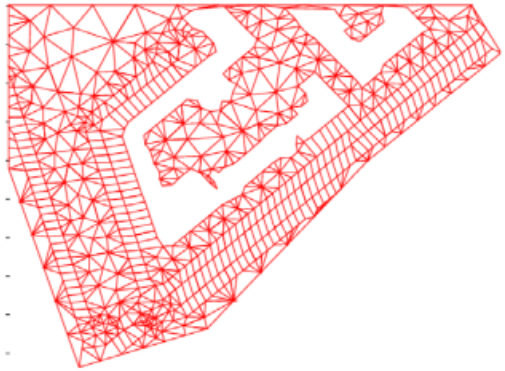
Stage 3: Detailed simulation of flooding

- **Necessary data**
  - Digital terrain model (DTM)





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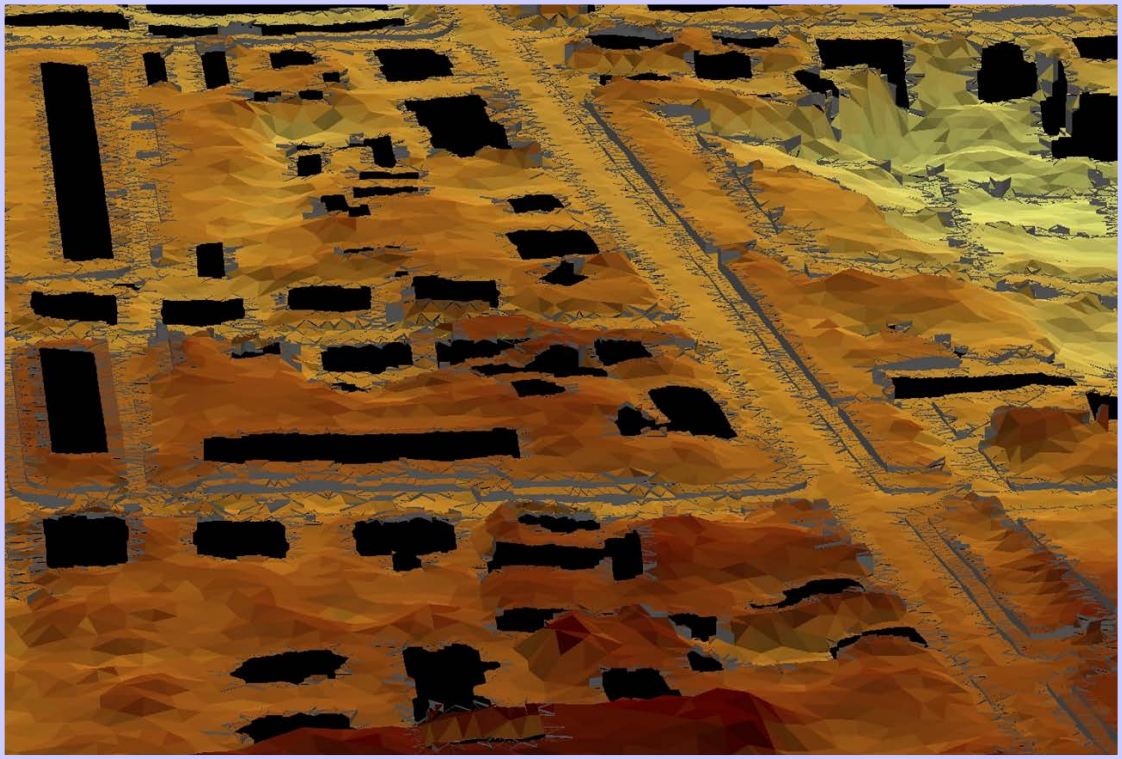
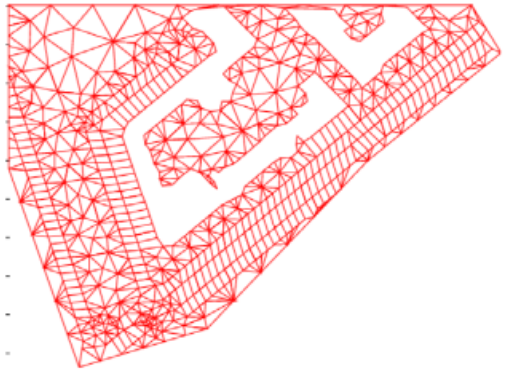
Stage 3: Detailed simulation of flooding

- **Necessary data**
  - Detailed simulation network (3D view)





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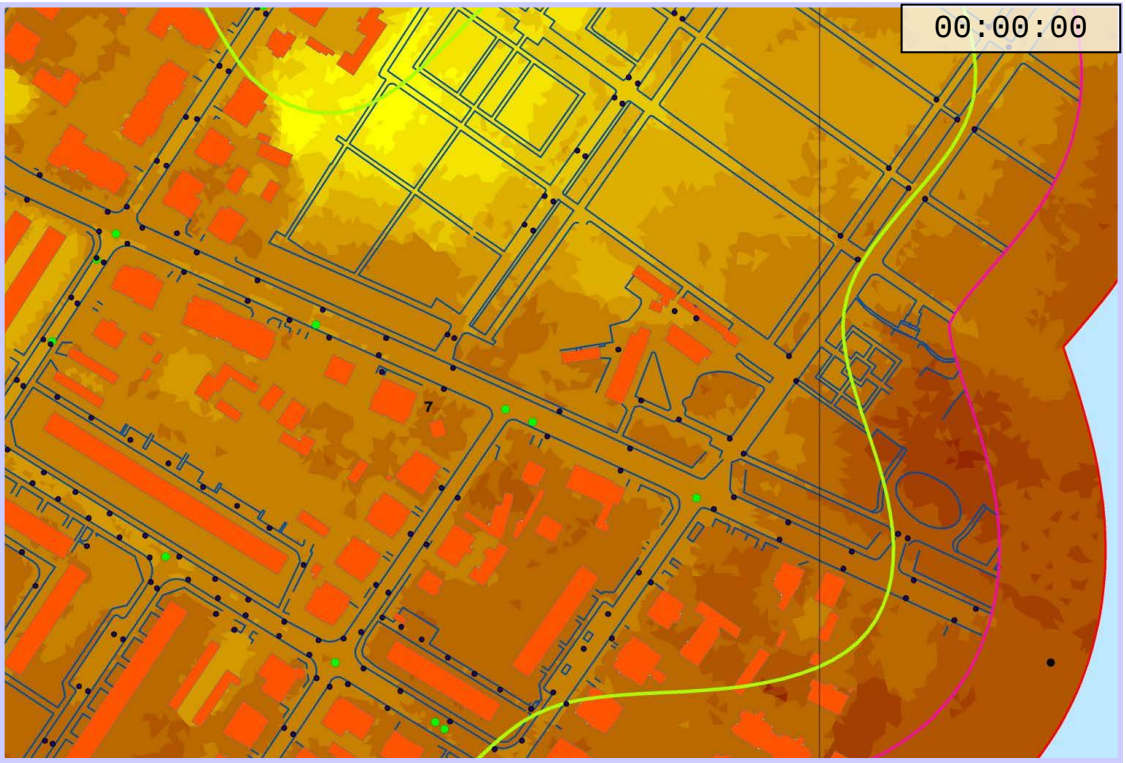
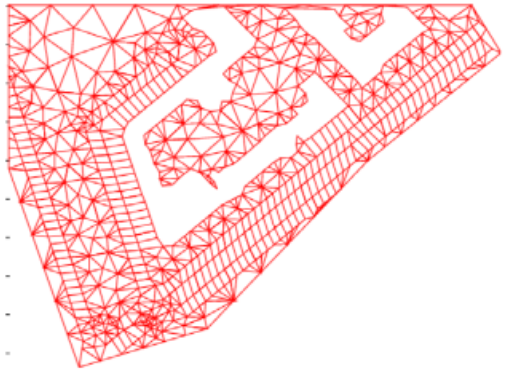
Stage 3: Detailed simulation of flooding

- **Results**
  - Water level on the surface, velocities, basis for detailed damage analysis





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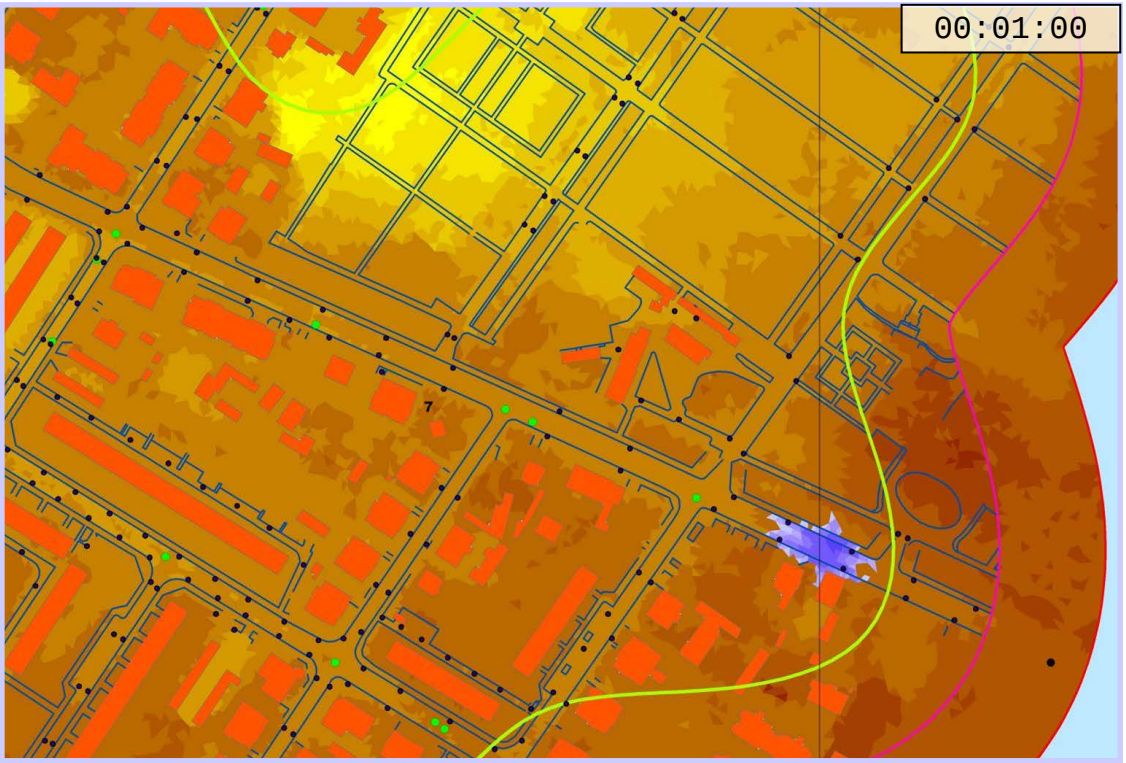

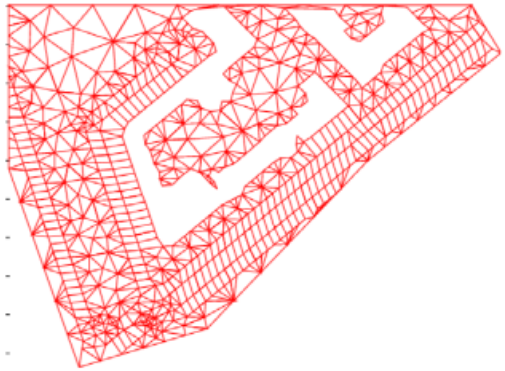

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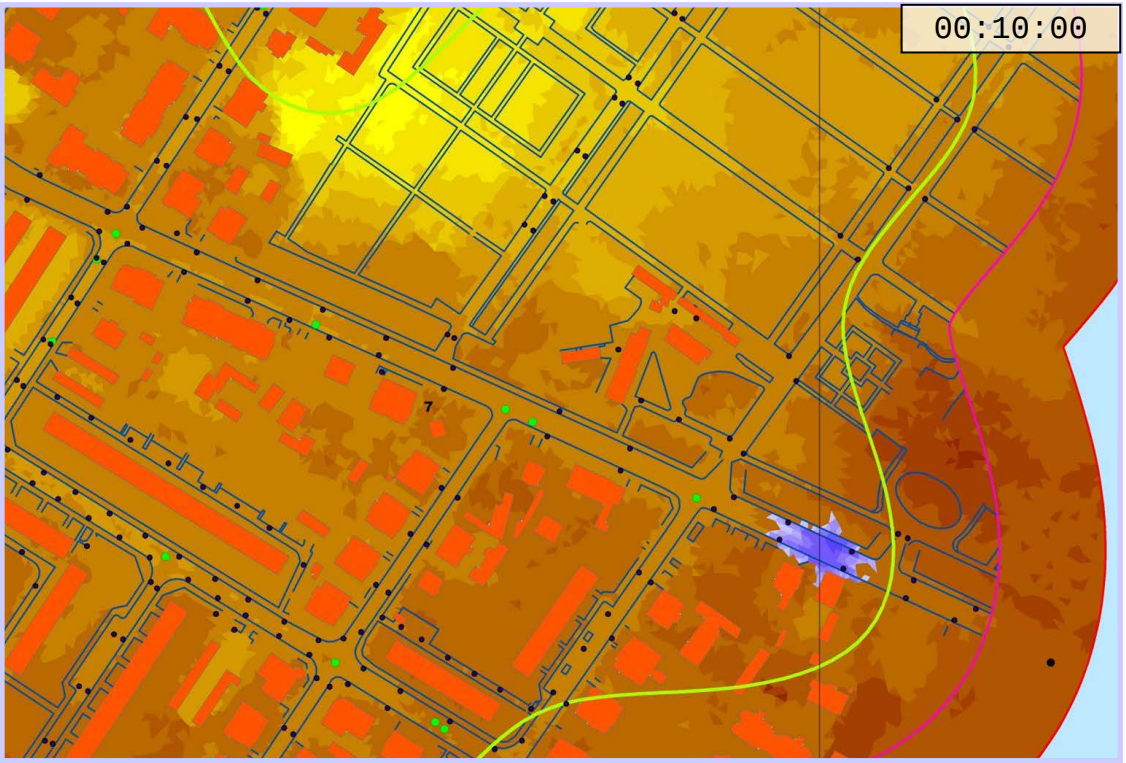

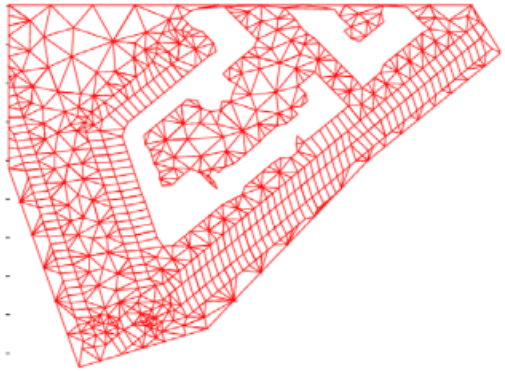

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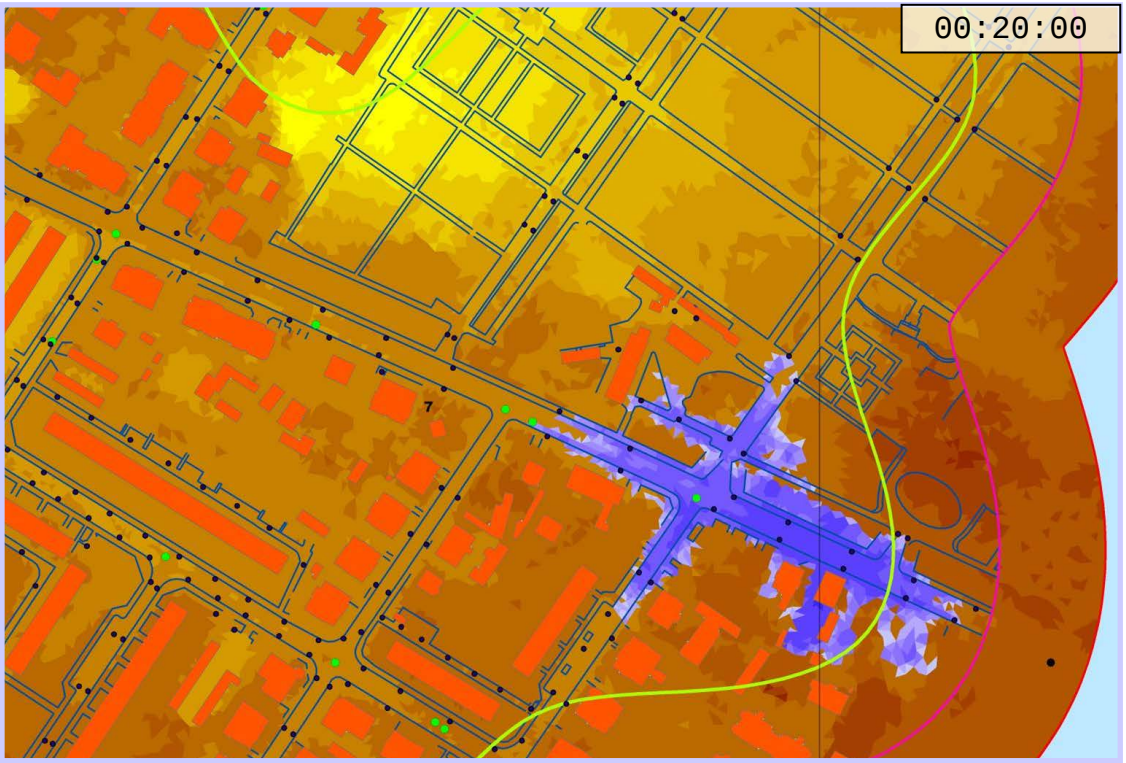

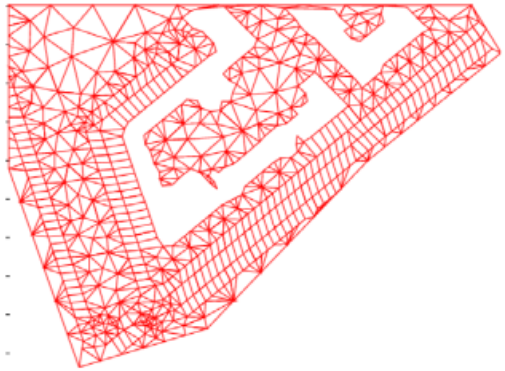

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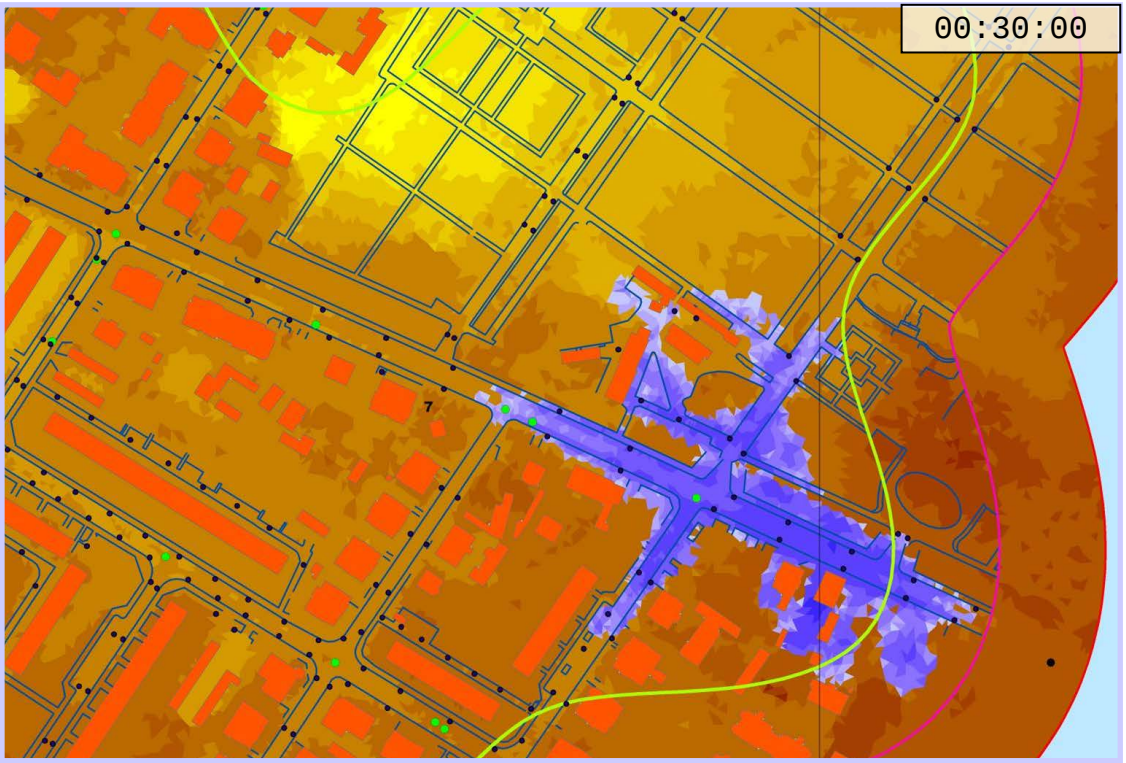

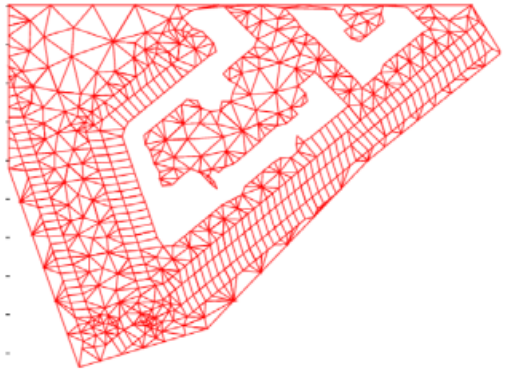

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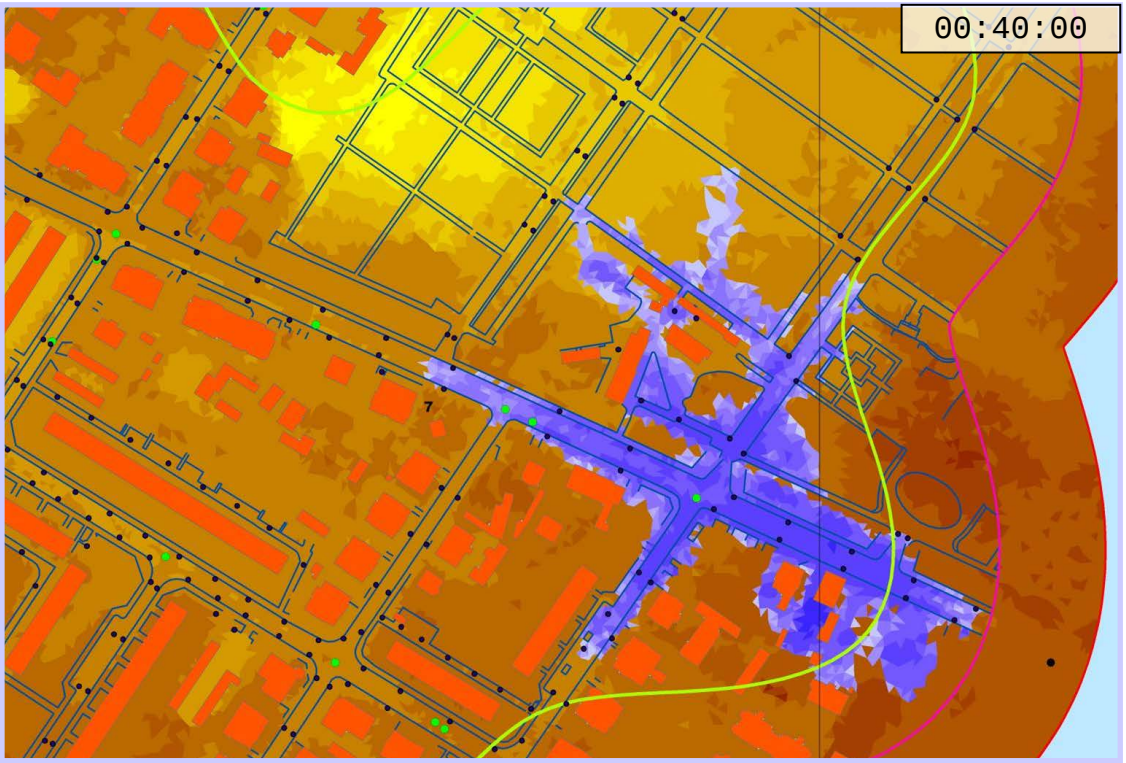

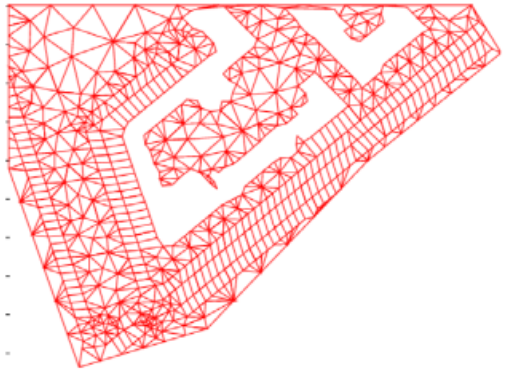

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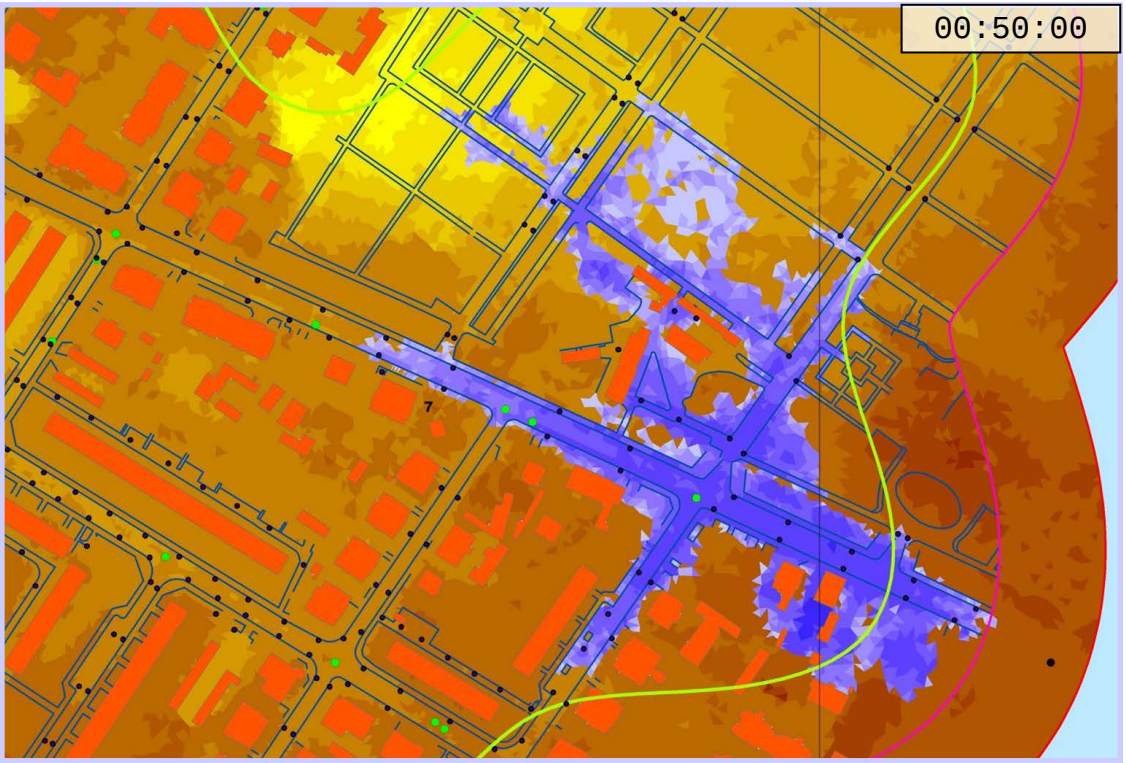

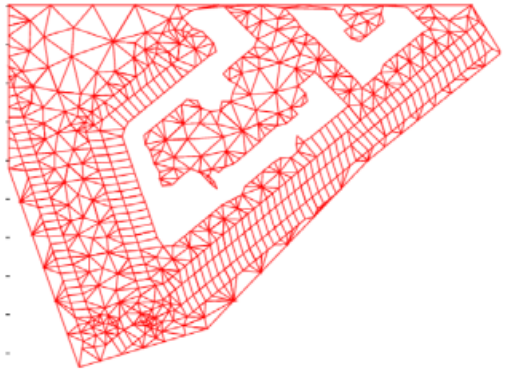

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Stage 3: Detailed simulation of flooding

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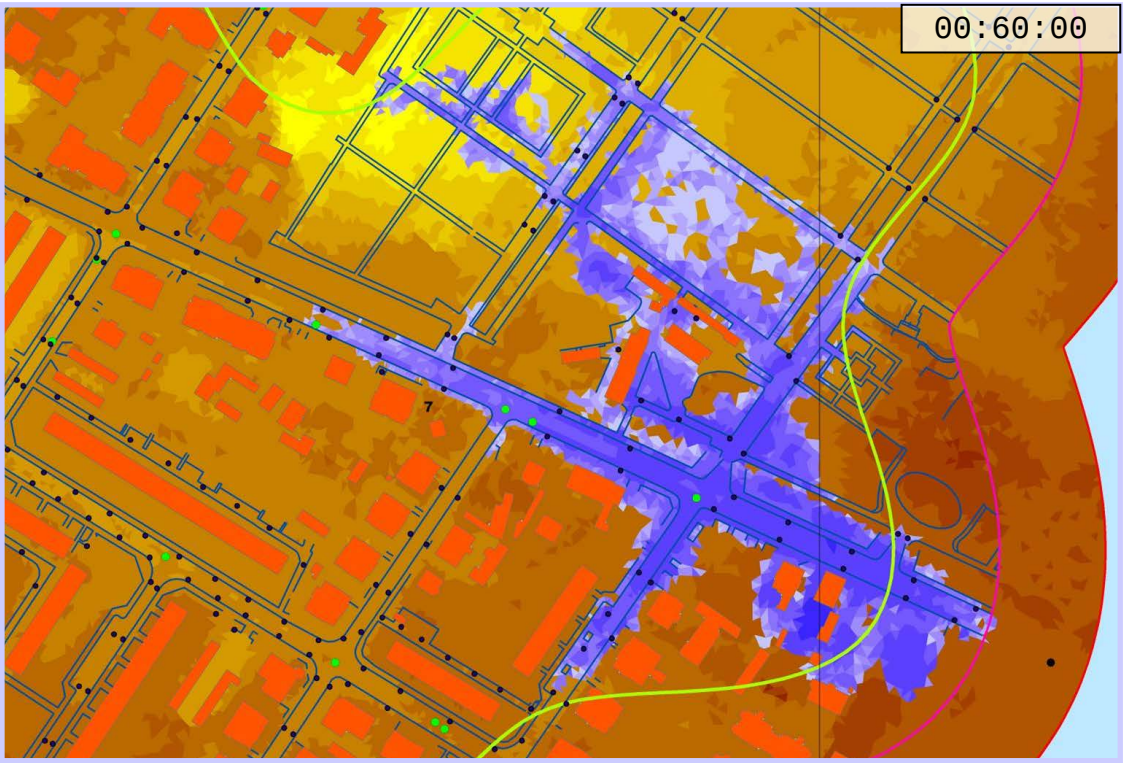

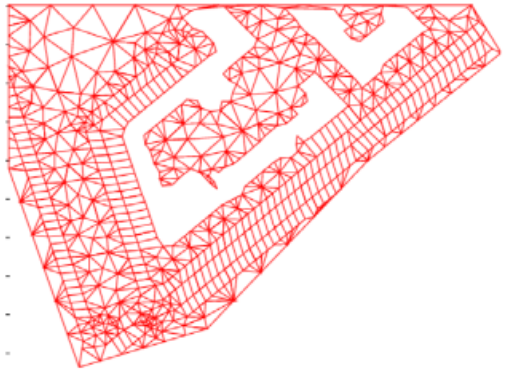

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Stage 3: Detailed simulation of flooding

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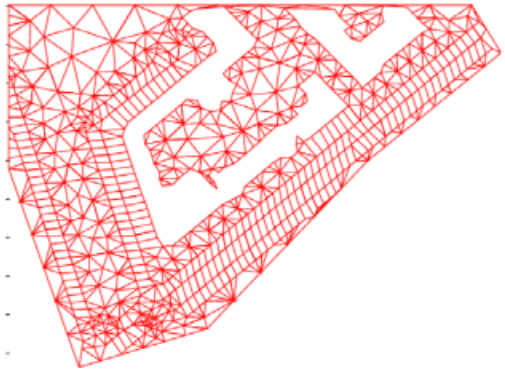

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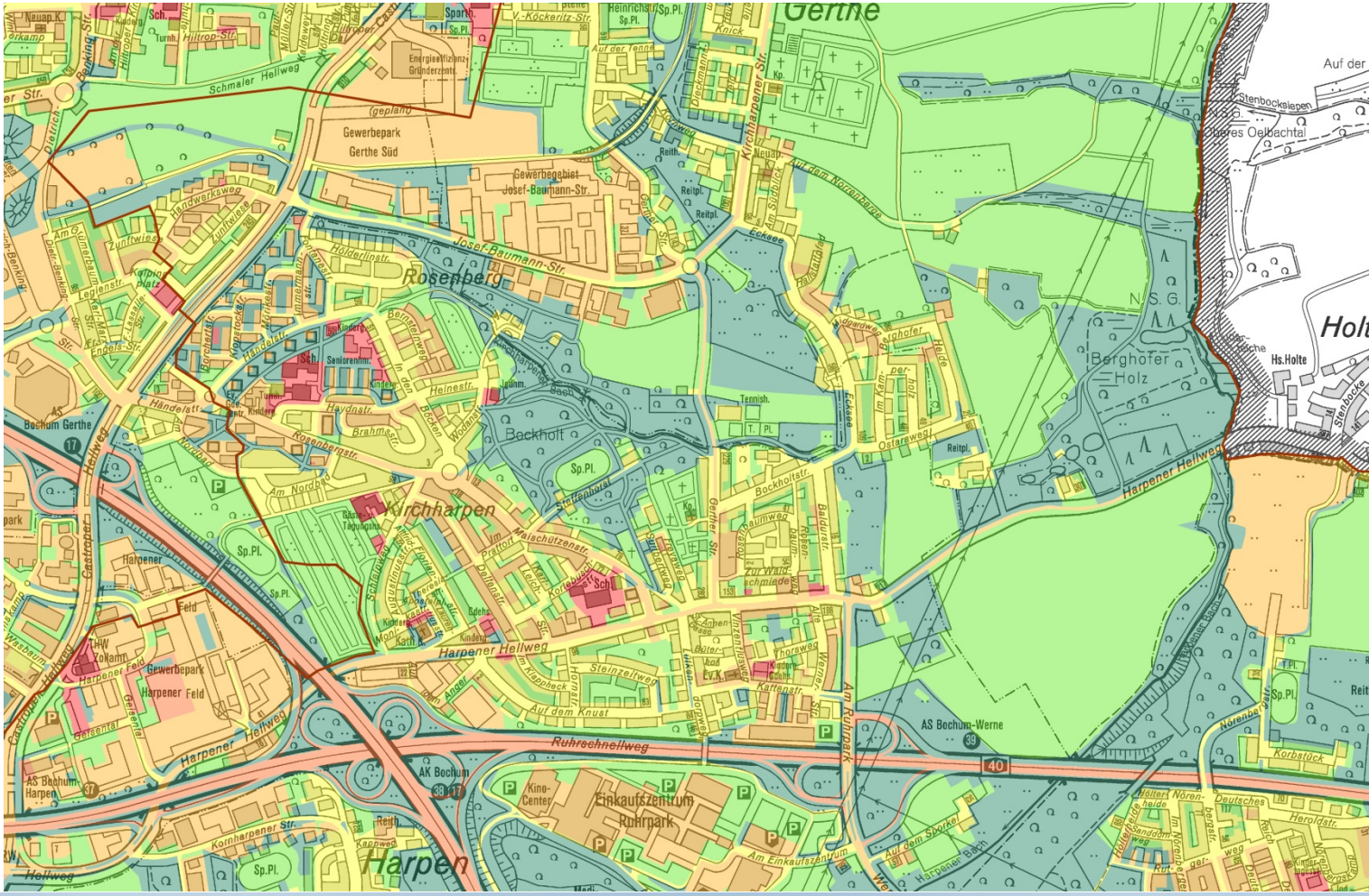
Stage 4: Definition of potential of damage

Potential of damage

Very low
low
moderat
Slight high
high
Very high



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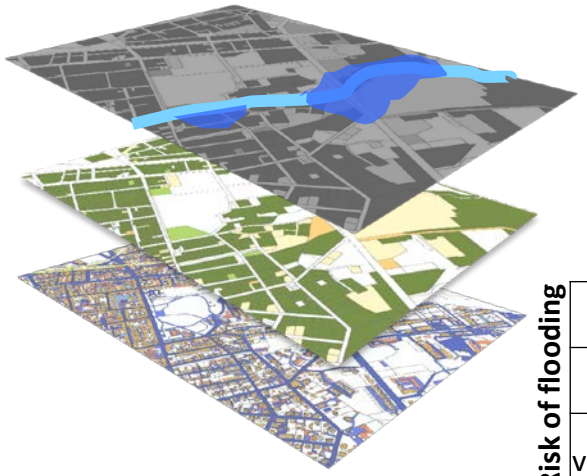
Stage 5: Mapping potential damage and risk of flooding



Potential of damage

Risk of flooding		very low	low	moderat	slight high	high	very high
		1	2	3	4	5	6
very low	1	1	1	2	2	2	3
low	2	1	2	2	3	3	4
moderat	3	2	2	3	3	4	5
slight high	4	2	3	3	4	4	5
high	5	2	3	4	4	5	6
very high	6	2	3	4	5	6	6

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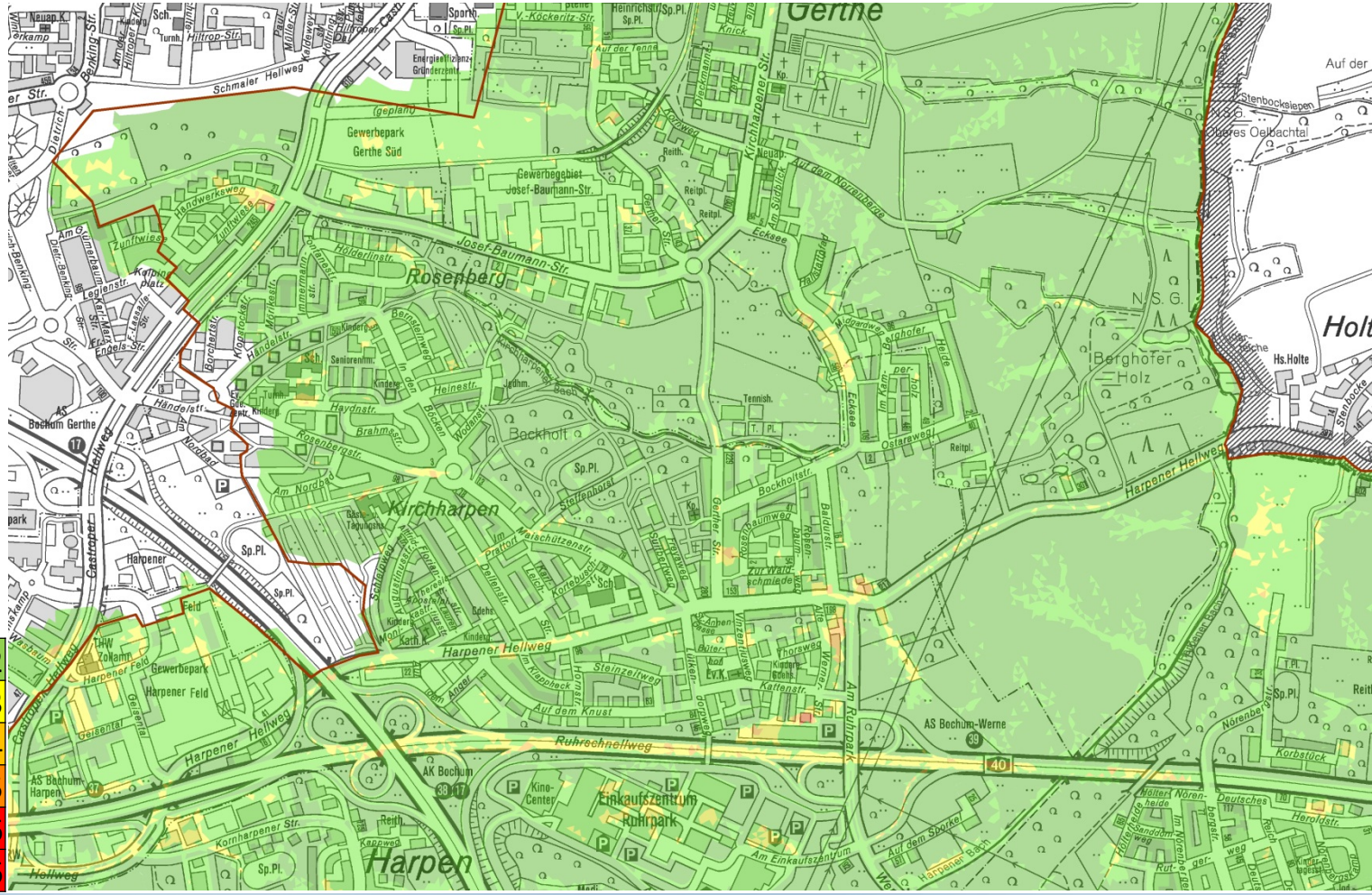
Stage 5: Mapping potential damage and risk of flooding



1	1	2	2	2	2
1	2	2	3	3	3
2	2	3	3	4	4
2	3	3	4	4	5
2	3	4	4	5	6
3	4	5	5	6	6

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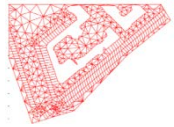
Summary


- **Detailed analysis of flooding for large urban areas is a problem of computational time**
- **Stepwise procedure recommended**
  - Identification of areas with flooding with normal sewer model
  - GIS-based analysis or rough 2-D surface model follows
  - Detailed analysis strongly recommended for areas with high risk
- **Definition potential of damage**
- **Mapping risk of flooding with potential of damage**
- **Remaining challenges**
  - Return periods, solutions, transfer to politician/public

1	1	2	2	2	2
1	2	2	3	3	3
2	2	3	3	4	4
2	3	3	4	4	5
2	3	4	4	5	6
3	4	5	5	6	6

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Summary

Water should not be treated as an enemy but as a friend

Living with water

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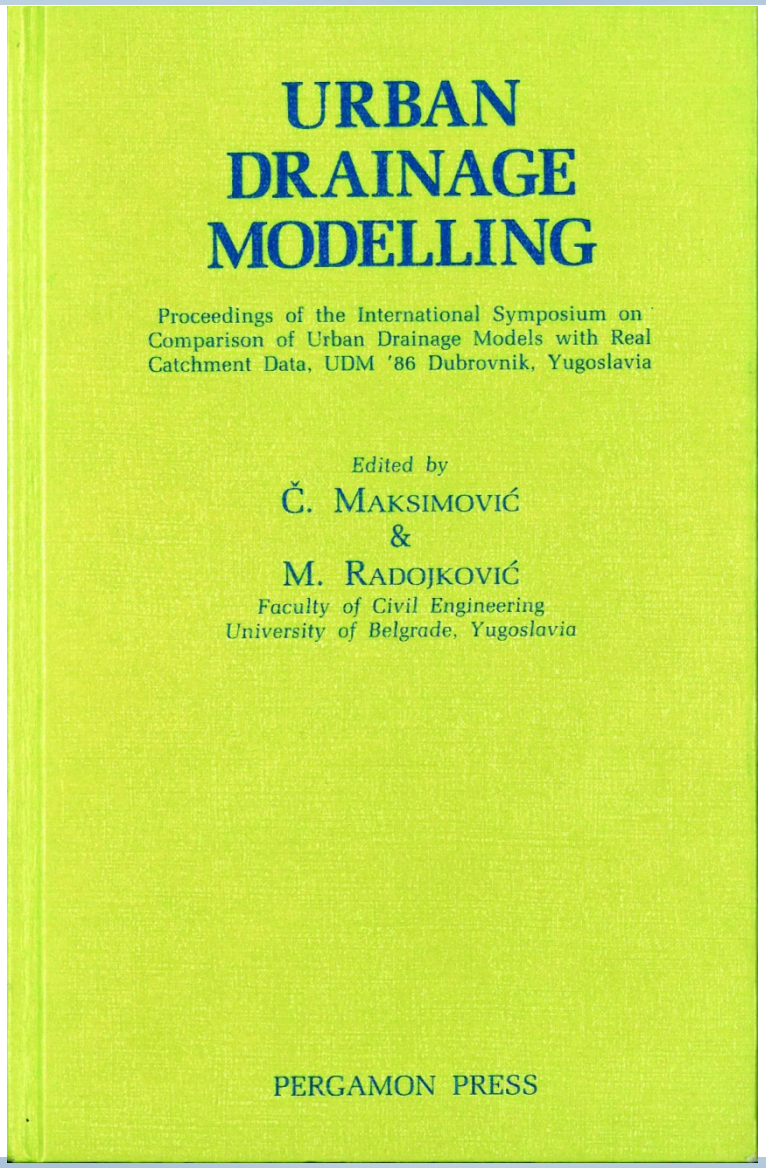
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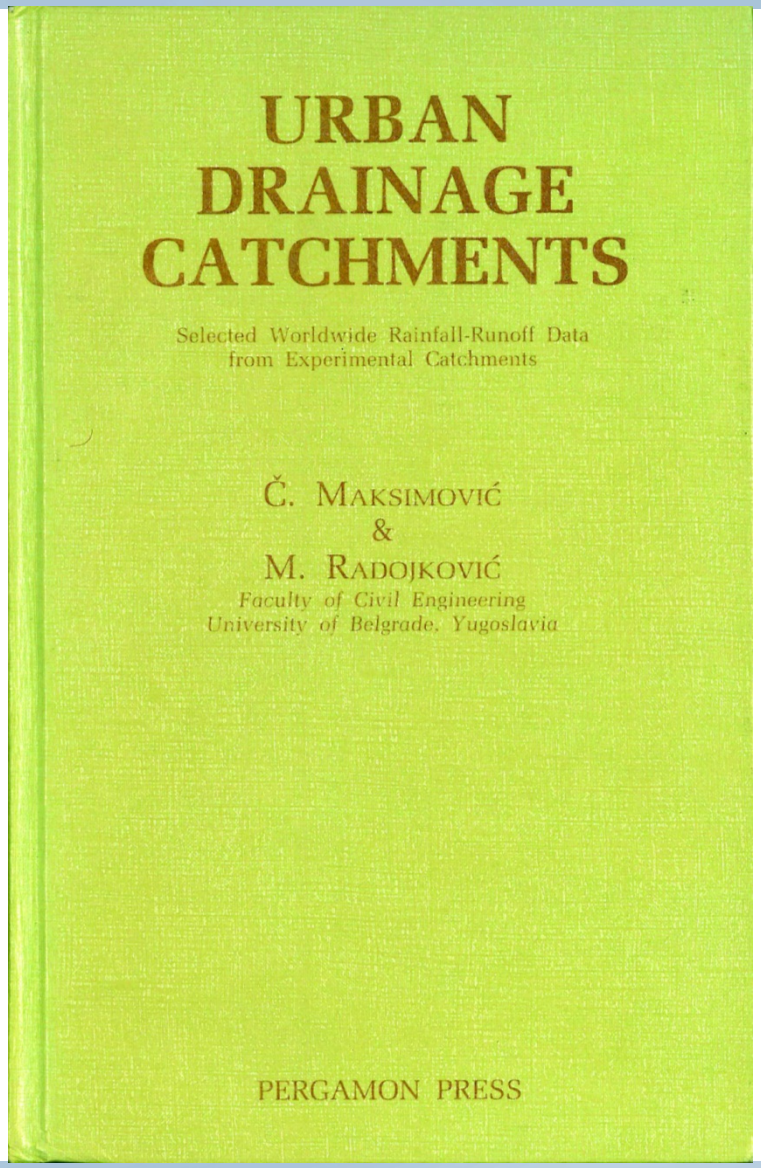
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