Flood Hazard & Risk Assessment

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Flood Hazard & Risk Assessment

- Flood Hazard Modeling
  - Modeling options
  - Data requirements
  - Examaples
- Quantifying potential damages
  - Elements at risk
  - Damage ratios
  - Data requirements
  - Risk Maps / Damage potential maps
  - Examples
- GIS tools

Flood Hazard

- Modeling Options
- 1D
- 2D
- 1D/2D-coupled

Example-1D

- Procedure:
  - Hydrological modeling
  - Surveying of cross sections
  - Hydraulic representation of terrain
  - 1D-Model (e.g. HEC-RAS)
  - Water level at cross sections
  - Extrapolation to area using a DTM (HEC-GeoRas)

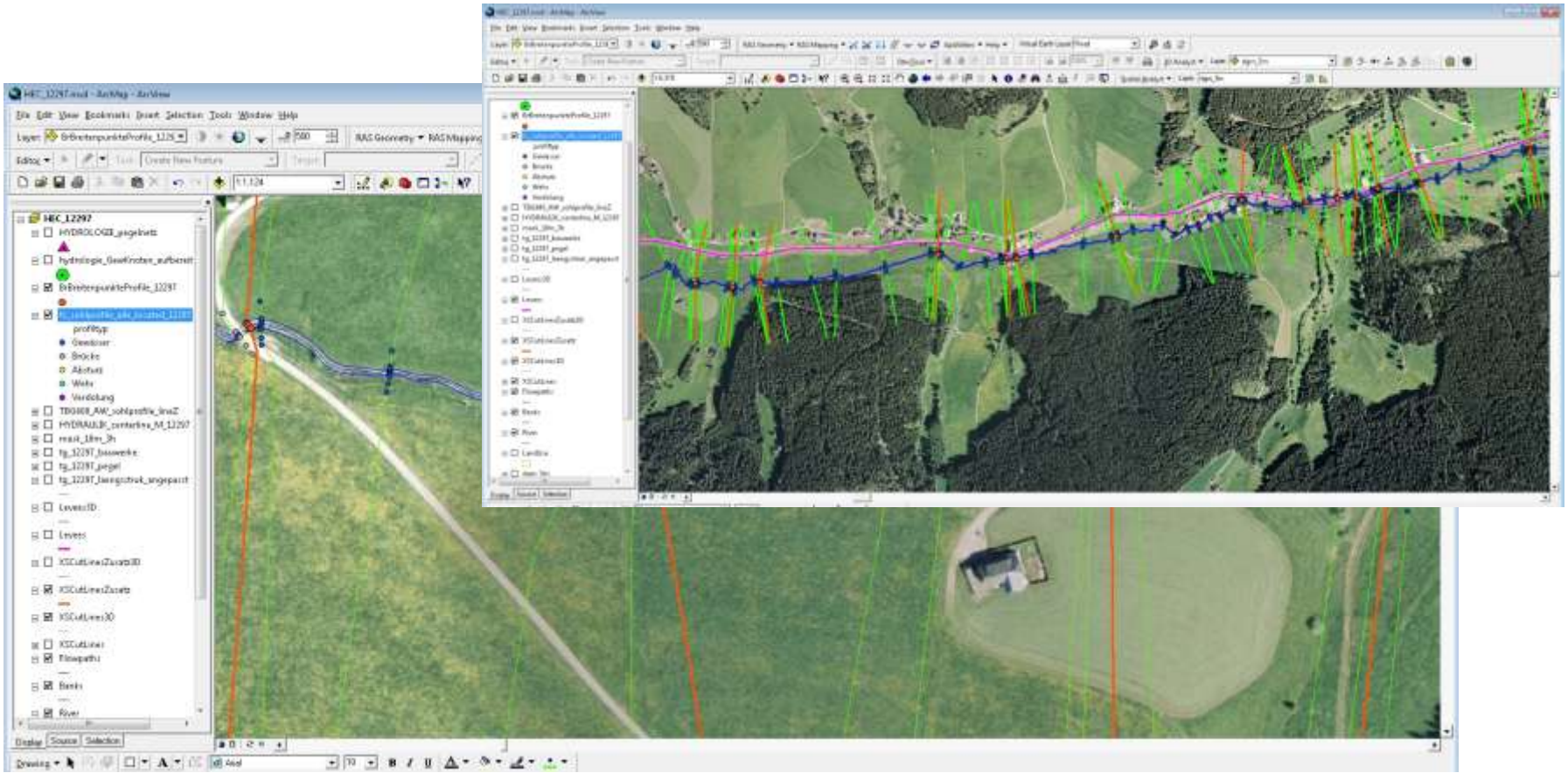
- Result: Flood inundation (hazard map)

1D

- E.g. HecRas

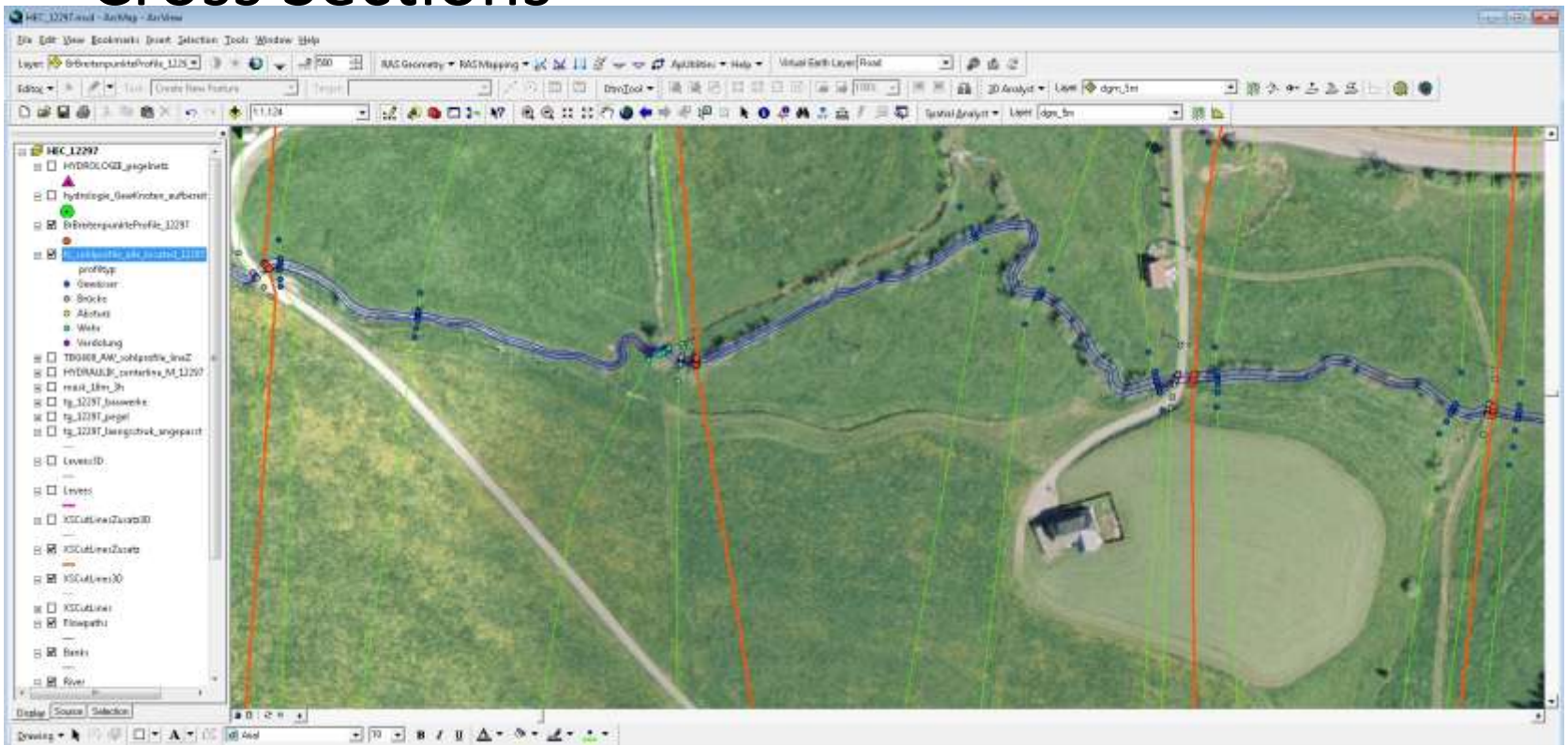
1D

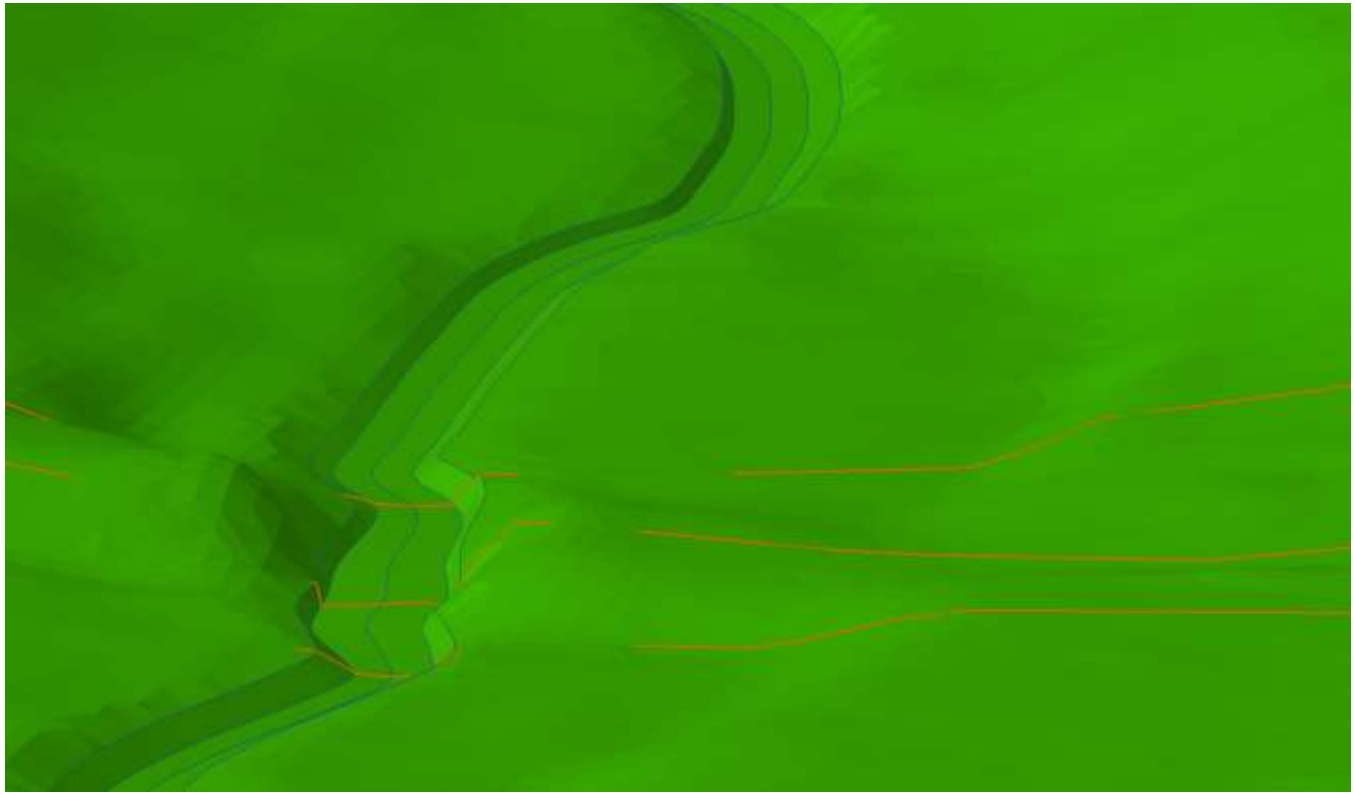
- Cross Sections



1D

- Cross Sections





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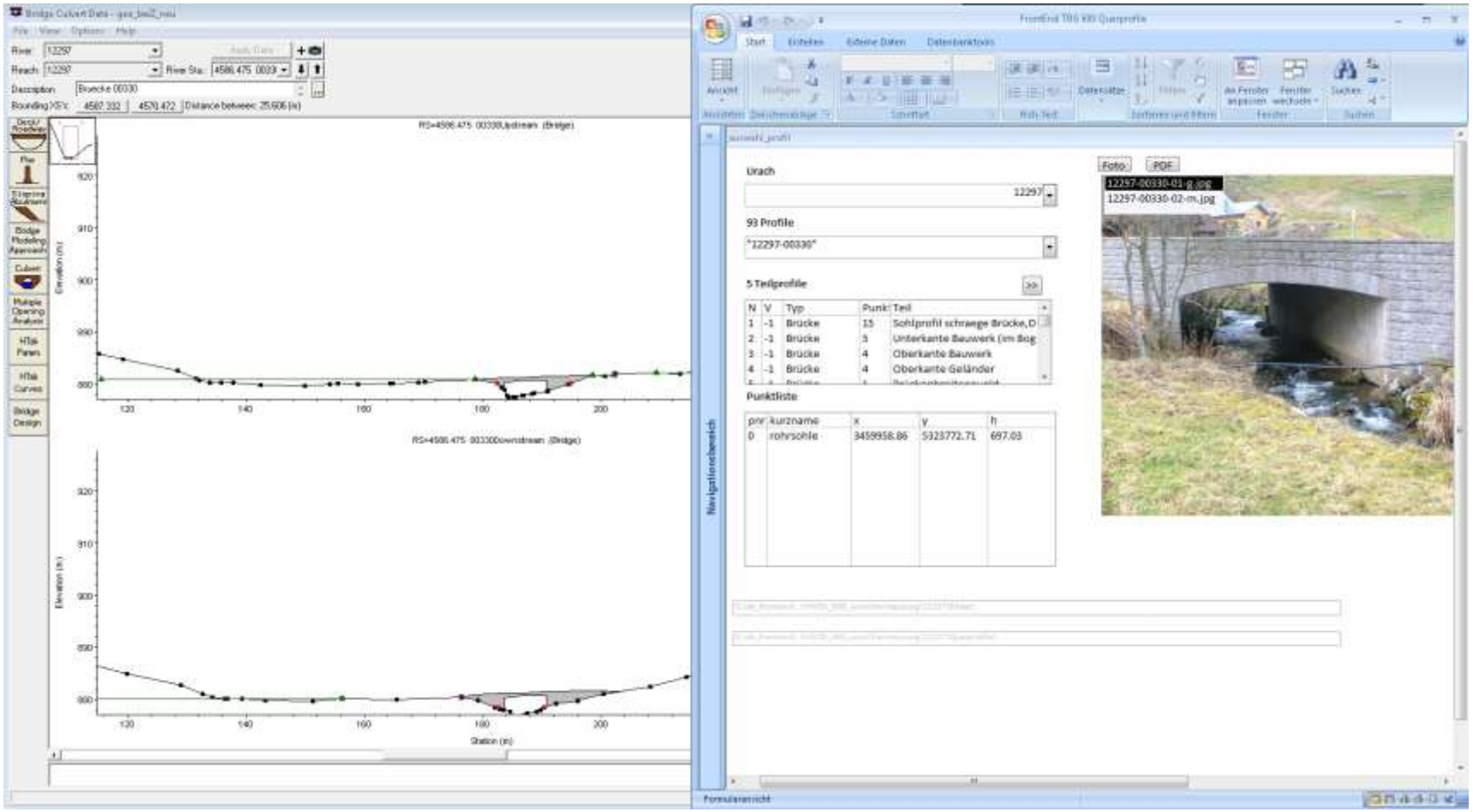

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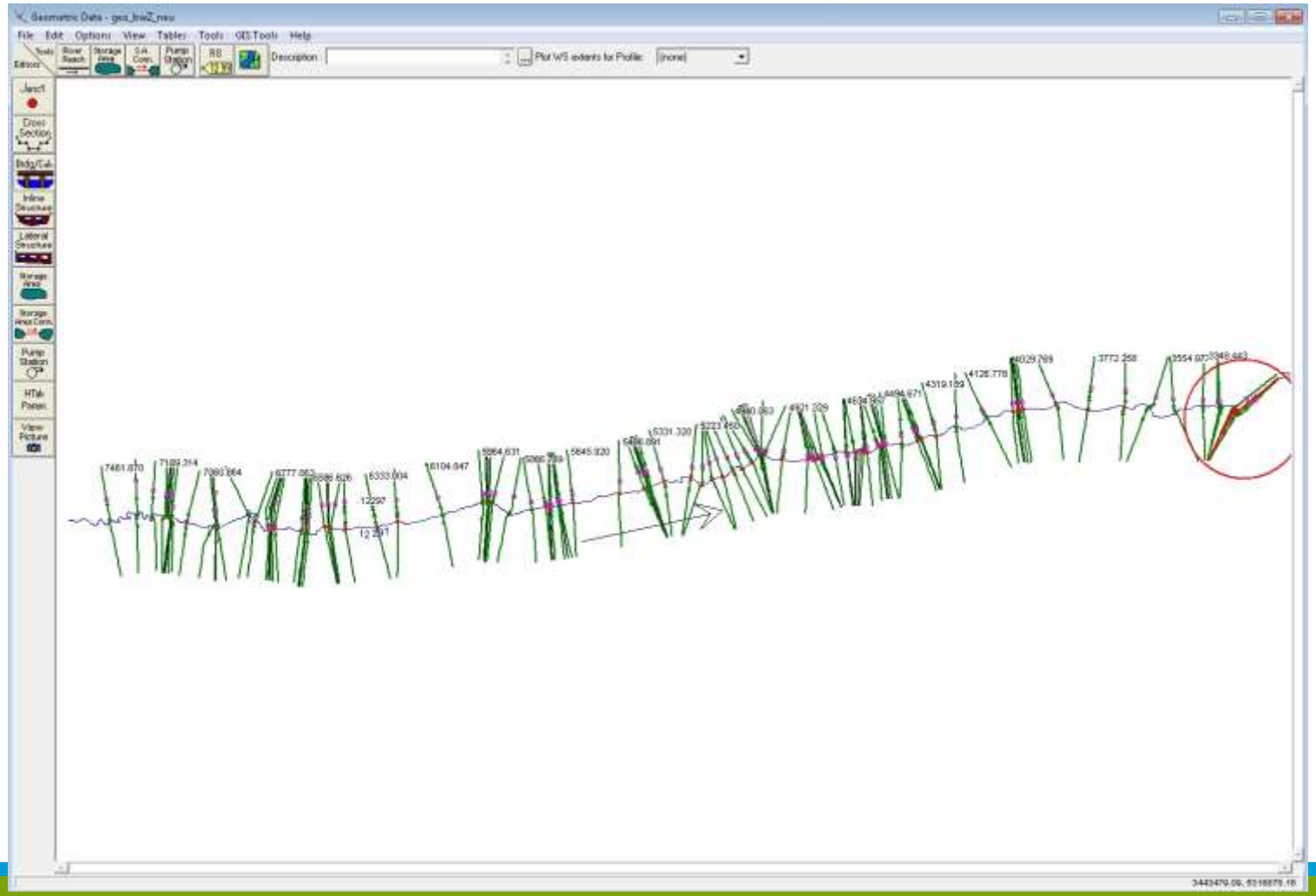

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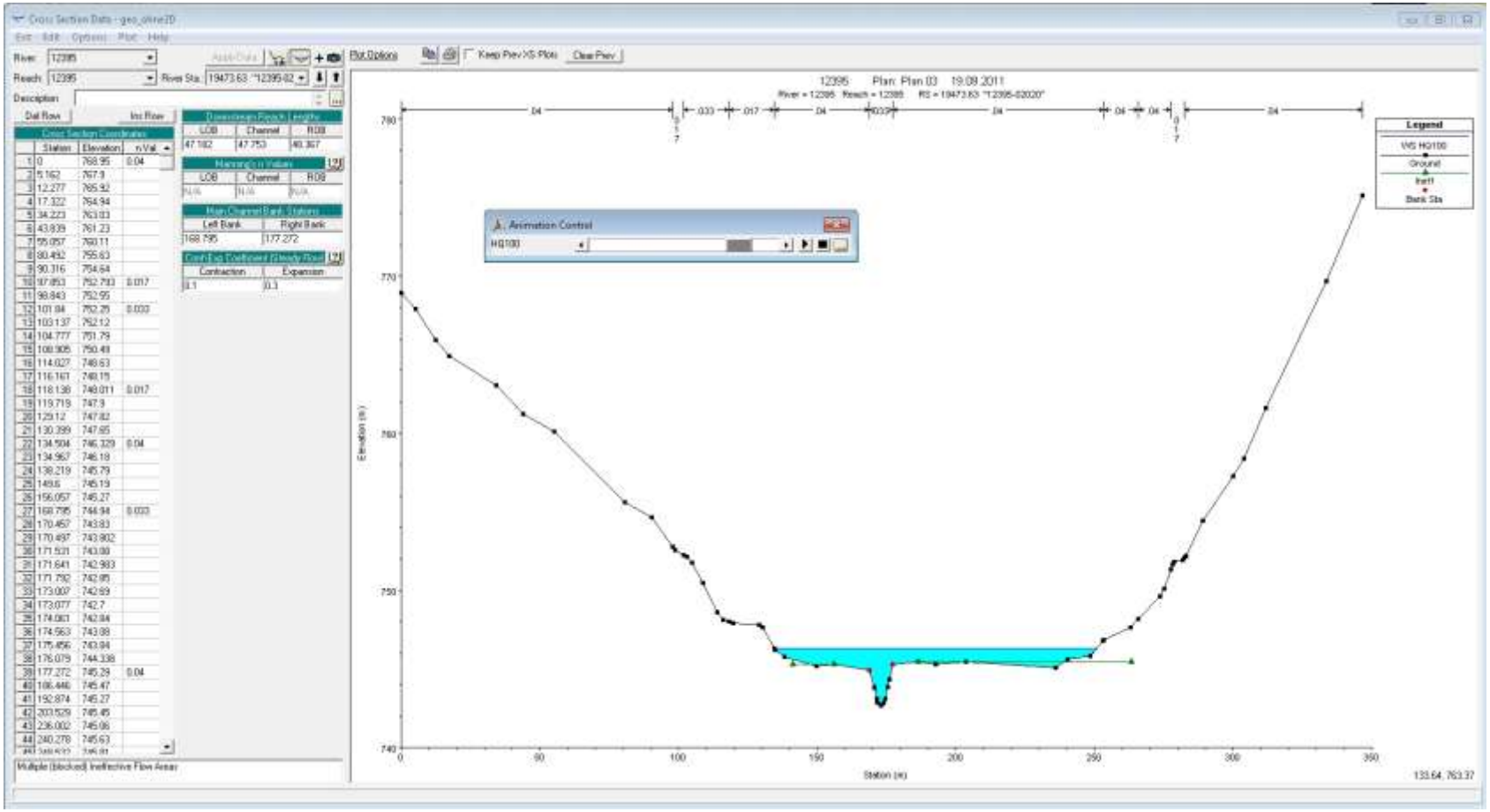

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Model chain summary

Zugeführte Wassermenge
- Niederschlagsmenge
- Zeitliche Verteilung

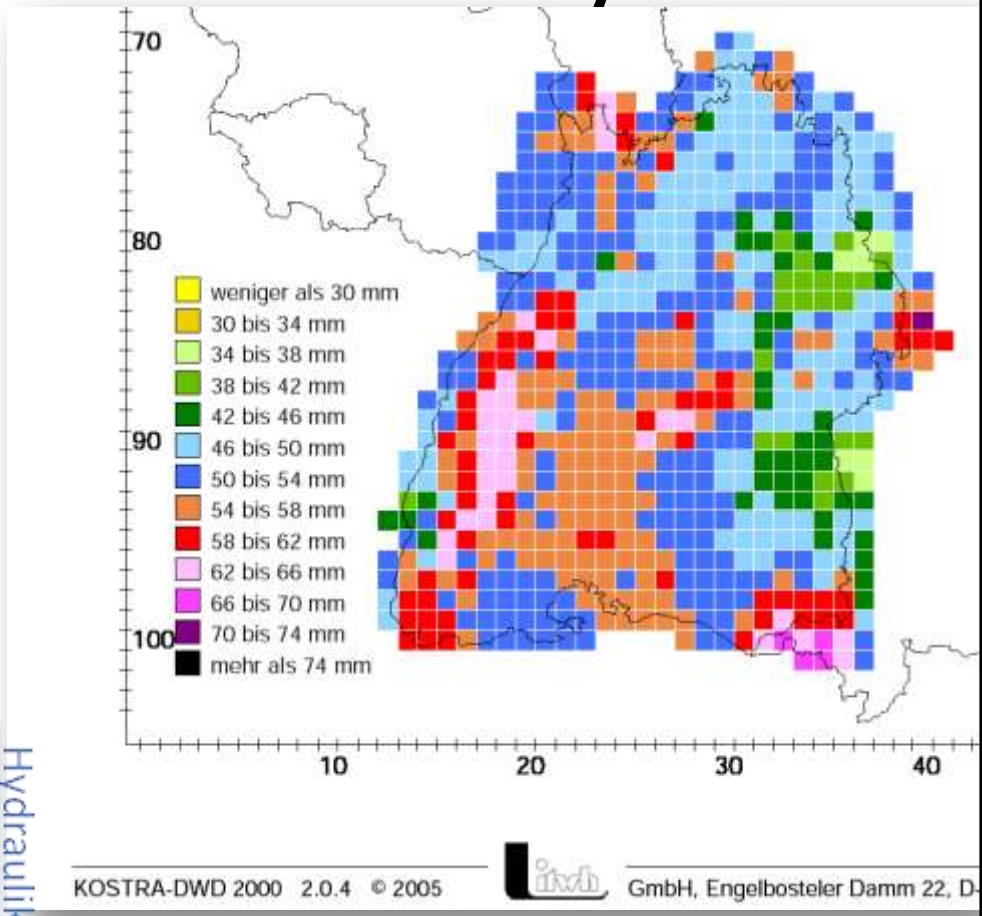
Klimamodell

Infiltration
- Boden
- Landnutzung
- Relief

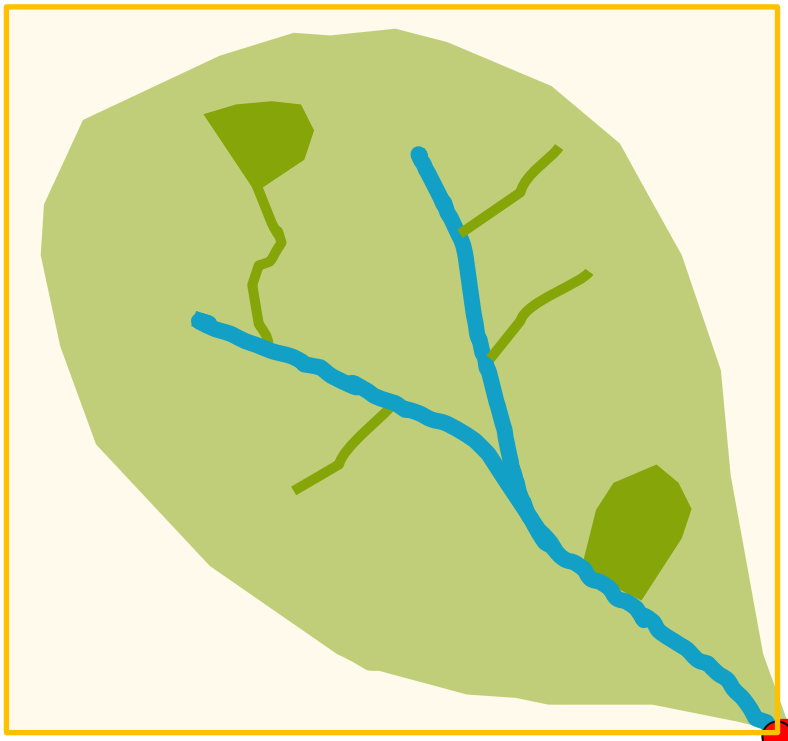
Hydrologie

Konzentration / Rückstau
- Relief
- Kleinstrukturen

Hydraulik

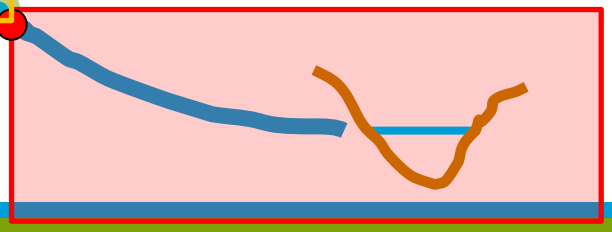


Hydrological Model



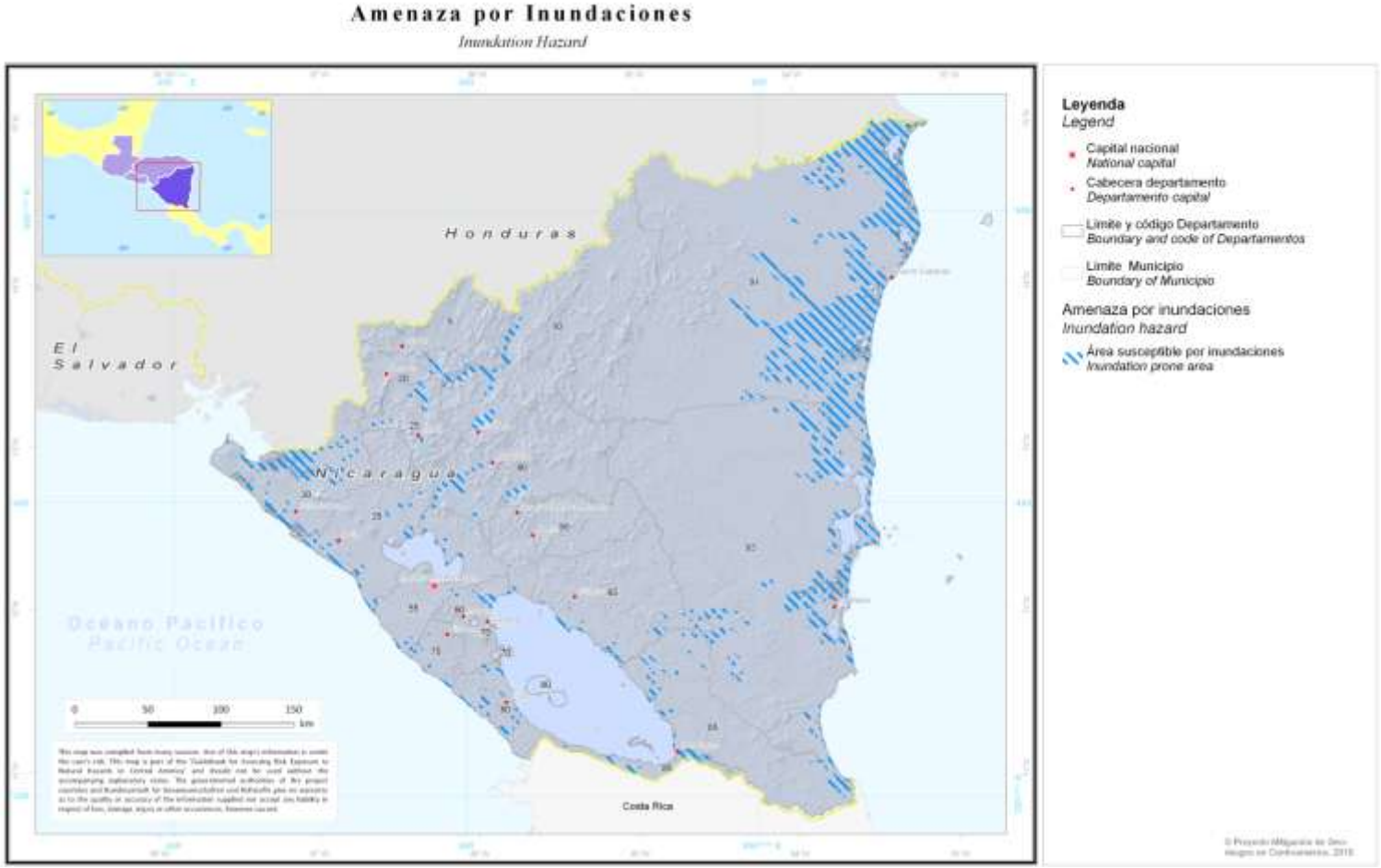
- Low resolution (1 km)
- Low demand on computational resources

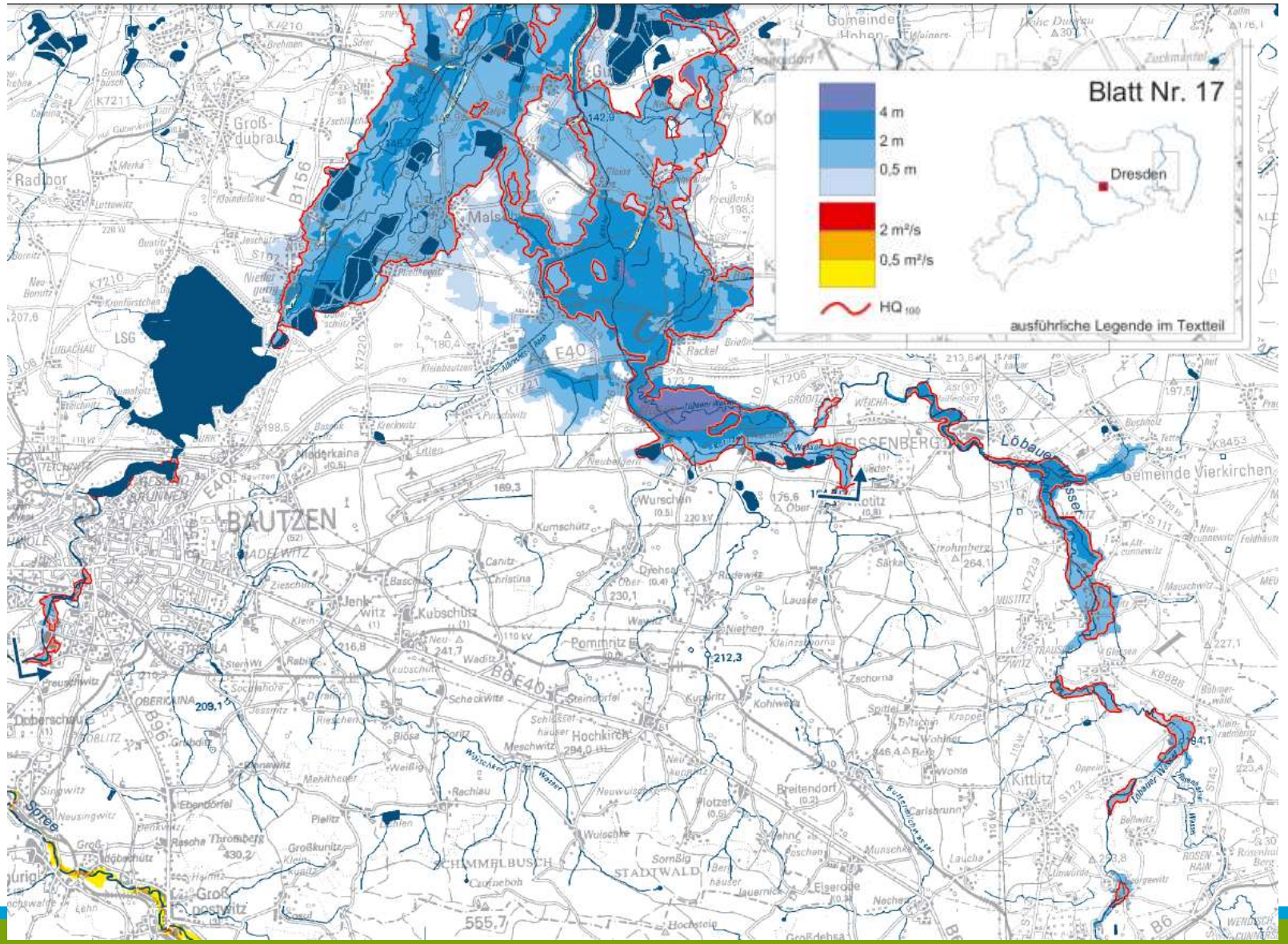
Flood Hazard Map

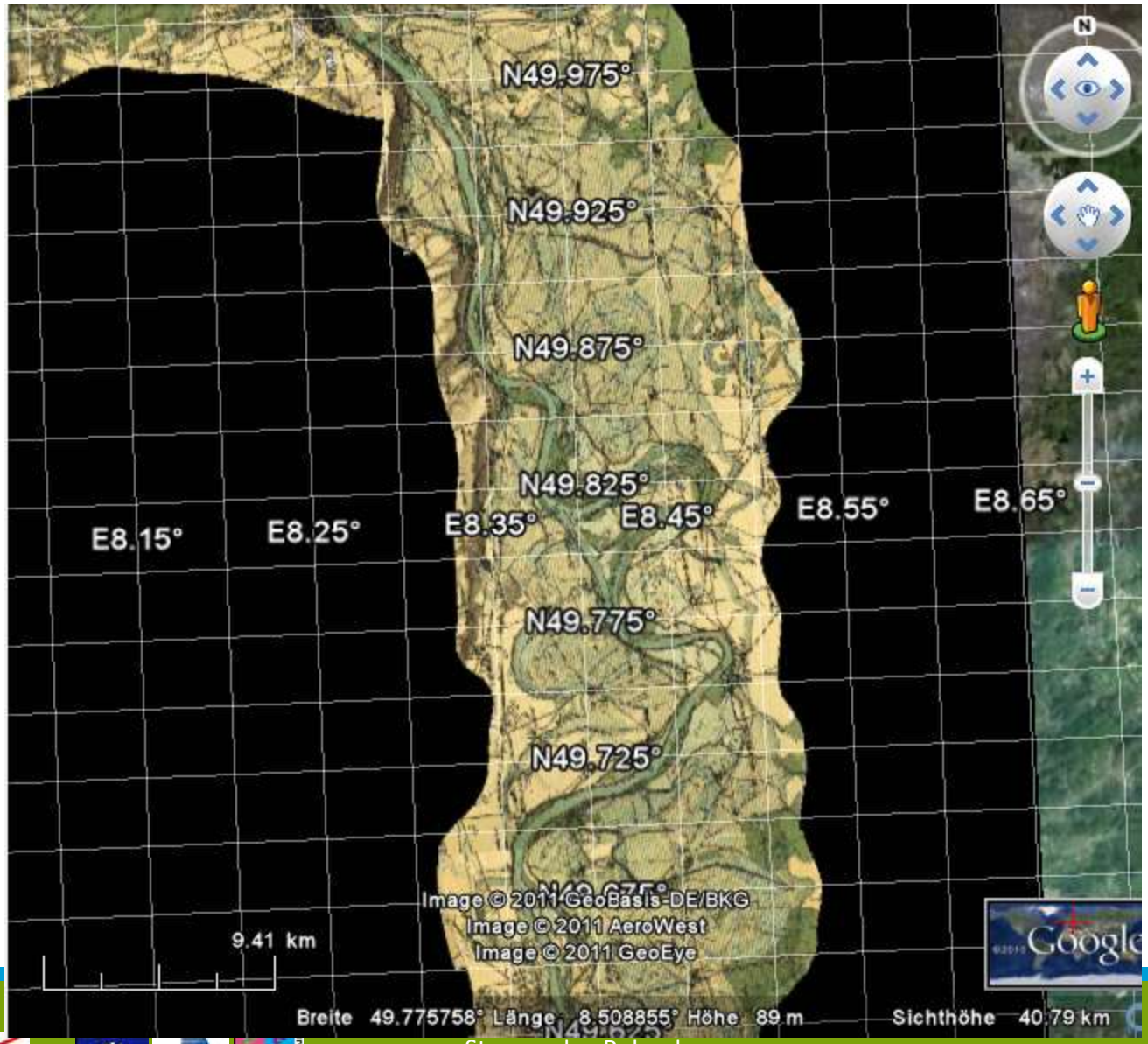


Examples

Hazard Maps


Amenaza por Inundaciones
Inundation Hazard
Honduras
El Salvador
Nicaragua
Costa Rica
Océano Pacífico
Pacific Ocean
0 50 100 150
km
Leyenda
Legend
Capital nacional
National capital
Cabecera departamento
Departamento capital
Límite y código Departamento
Boundary and code of Departamentos
Límite Municipio
Boundary of Municipio
Amenaza por inundaciones
Inundation hazard
Área susceptible por inundaciones
Inundation prone area


Blatt Nr. 17
4 m
2 m
0,5 m
2 m²/s
0,5 m²/s
HQ 100
ausführliche Legende im Textteil
Dresden
BAUTZEN
Wurschen
Kubschütz
Pommritz
Hochkirch
Kittlitz
Breitendorf
Gemeinde Vierkirchen
Löbauer Wasser
Spree
Großdubrau
Radibor
Mals
Niederkaina
Doberschau
Großpostwitz
Jenkwitz
Rachlau
Meschwitz
Steindorfel
Schmerlitz
Carlsbrunn
Rosenhain
Stadtwald
Zschorna
Niethen
Lauske
Sätka
Strohmberg
Kohlwese
Spittel
Wohlsit
Wiesa
Oppeln
Bellwitz
Munschke
Laucha
Elsergrabe
Nechern
Hochstein
Großdehsa
Wuischke
Sornßig
Lauernick
Ebendörfel
Pielitz
Singwitz
Neusingwitz
Großkunitz
Rascha Thronberg
Mehltheuer
Ebersbach
Weißig
Blösa
Schackwitz
Oberkaina
Canitz-Christina
Kumschütz
Pulschwitz
Kleinbautzen
Neubarjern
Rackel
Gemeindeteil Hohen
Kolmen
Zschornaer Wasser
Butterwitzbach
Wasser
Weißeritz
Lausitzer Neiße
Lutter
Lettewitz
Merka
Bremen
Schönbrunn
Quoitz
Neu-Quoitz
Nieder-Gurig
Ober-Gurig
Kleinsaubernitz
Neu-Bonnitz
Bonnitz
Oberuhna
Kreckwitz
Basank
Baschütz
Drehsa
Ober-Drehsa
Rietschen
Jessnitz
Sollschwitz
Stannewitz
Gröditz
Kleinsaubernitz
Neu-Jänkendorf
Kleinjänkendorf
Kleinradmeritz
Kleinradmeritz
Kleinradmeritz



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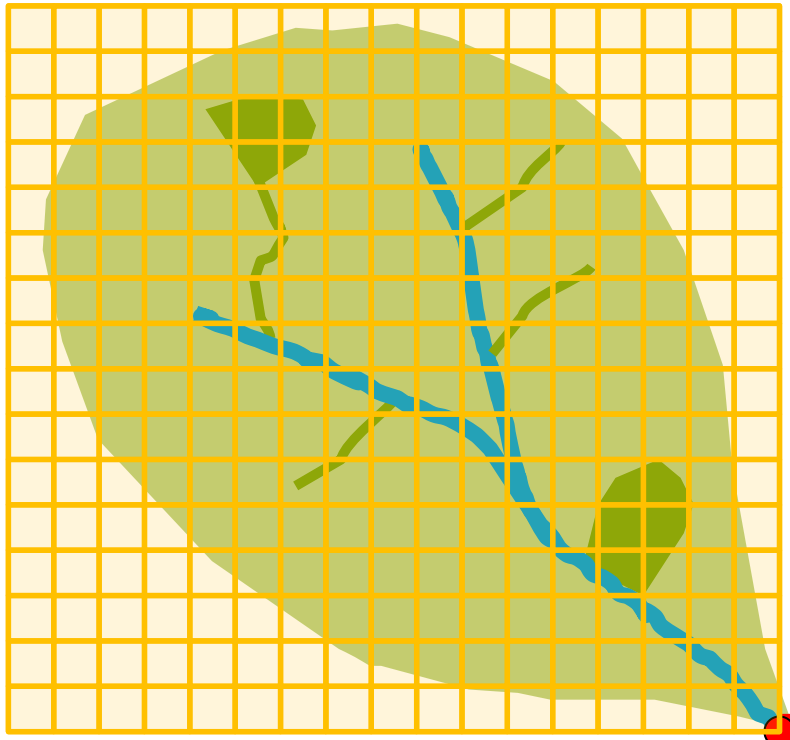
2D

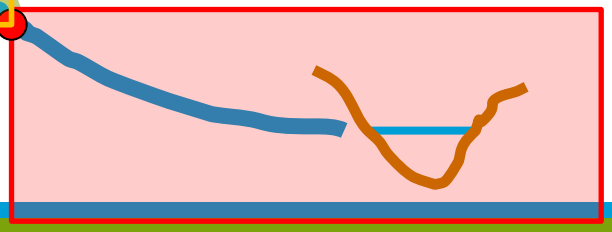
- Computationally more demanding because of ever increasing DEM resolution

Torrential rain/ flash flood Hazard Map



- High resolution (1m)
- High demand on computational resources

Flood Hazard map



Examples

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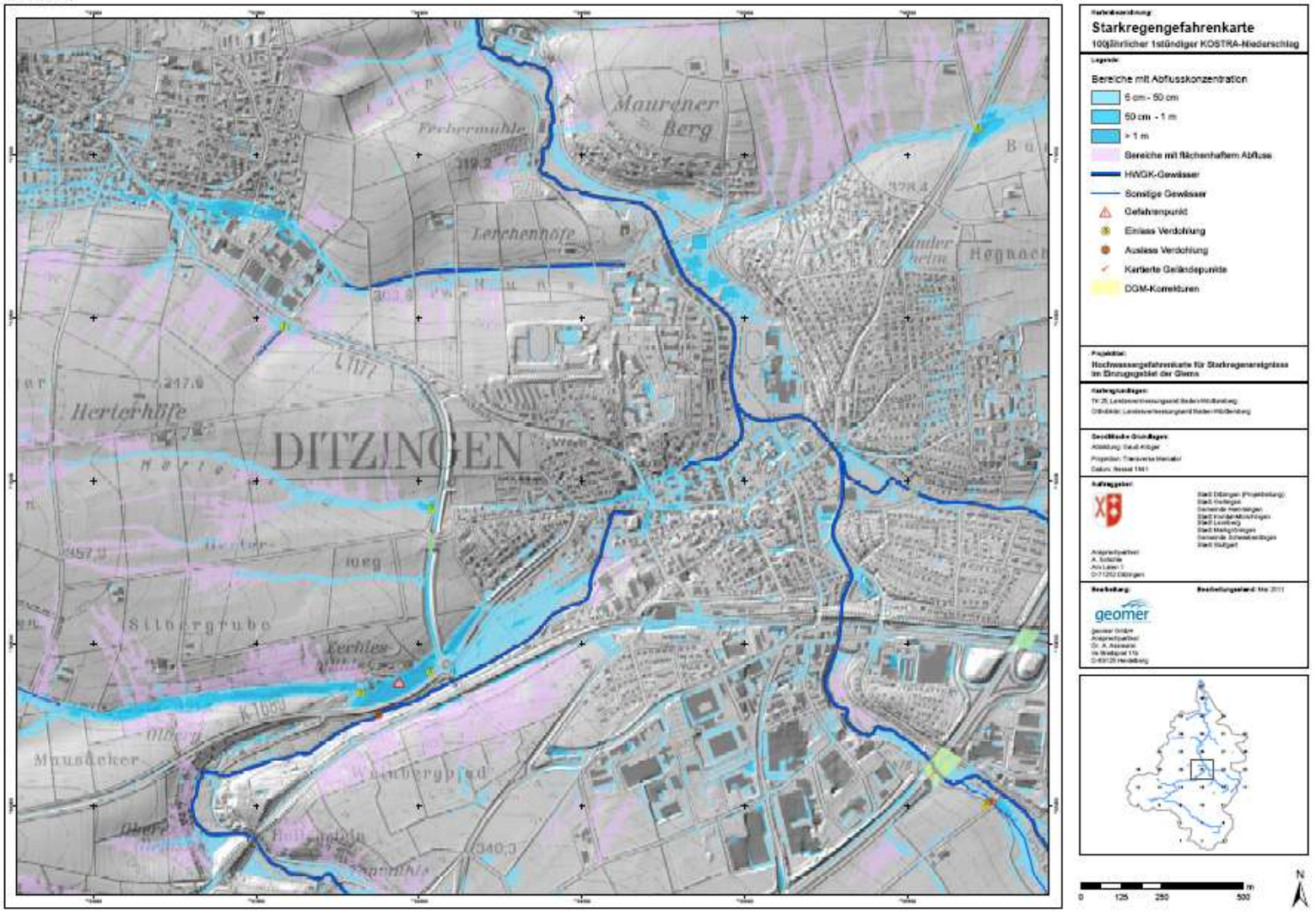
Karte Nr.: 21



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Validation

Data requirements

Data preparation: DTM is crucial

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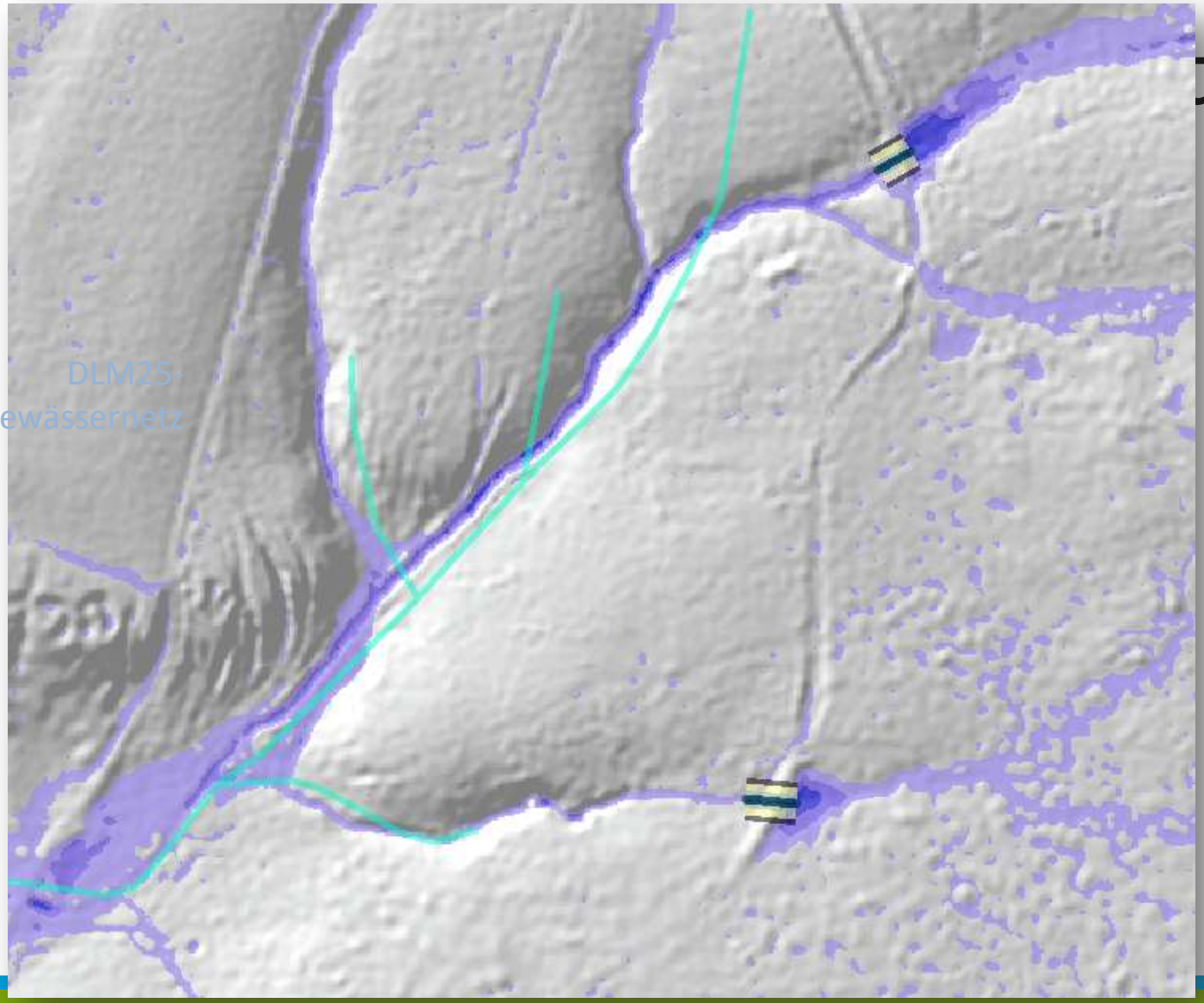
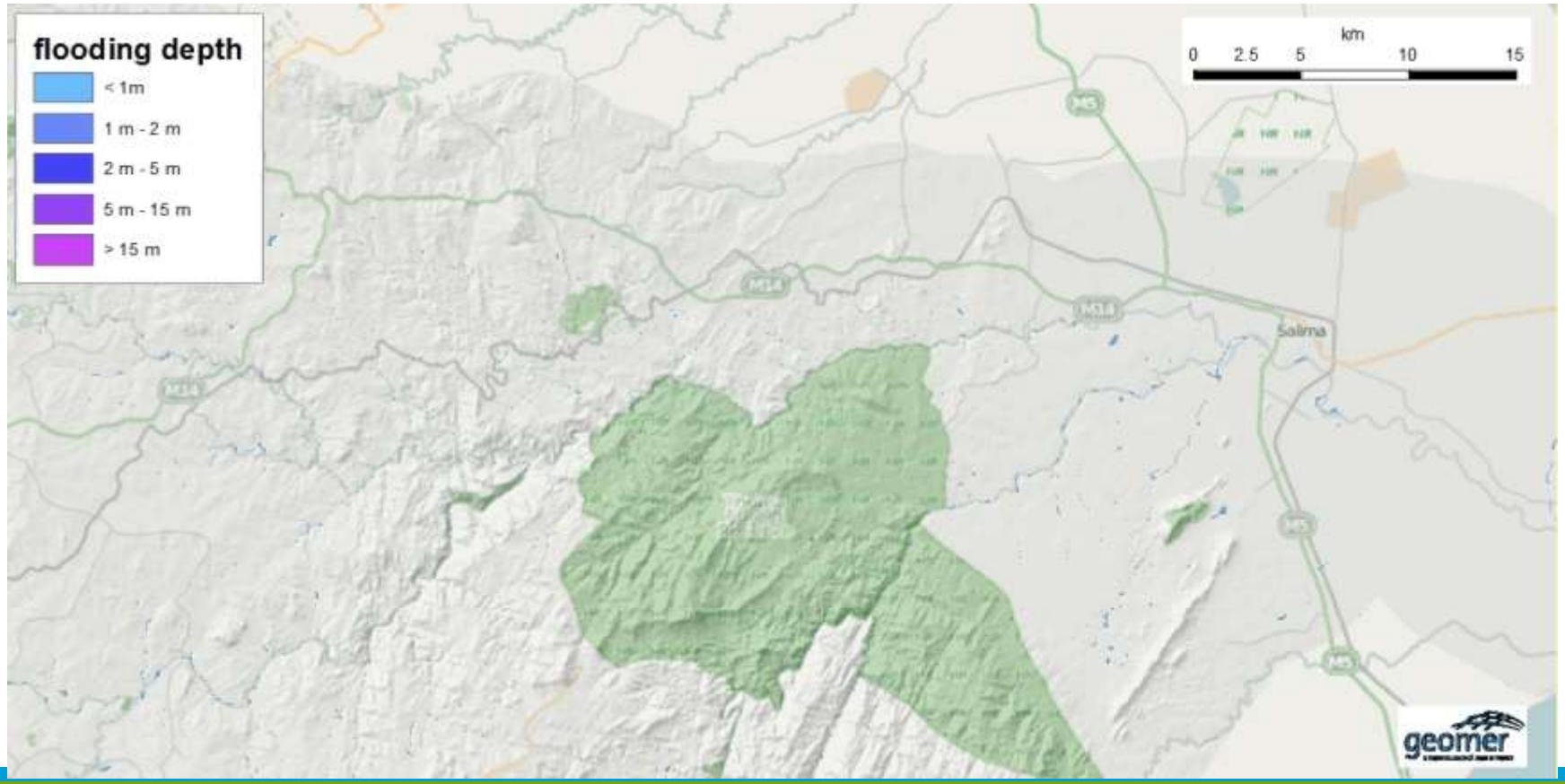


DTM modifications are required!



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Identifying Potential damages (Elements at Risk):

Identifying Potential damages (Elements at Risk):

1. Causes
2. Types
3. Evaluation and quantification

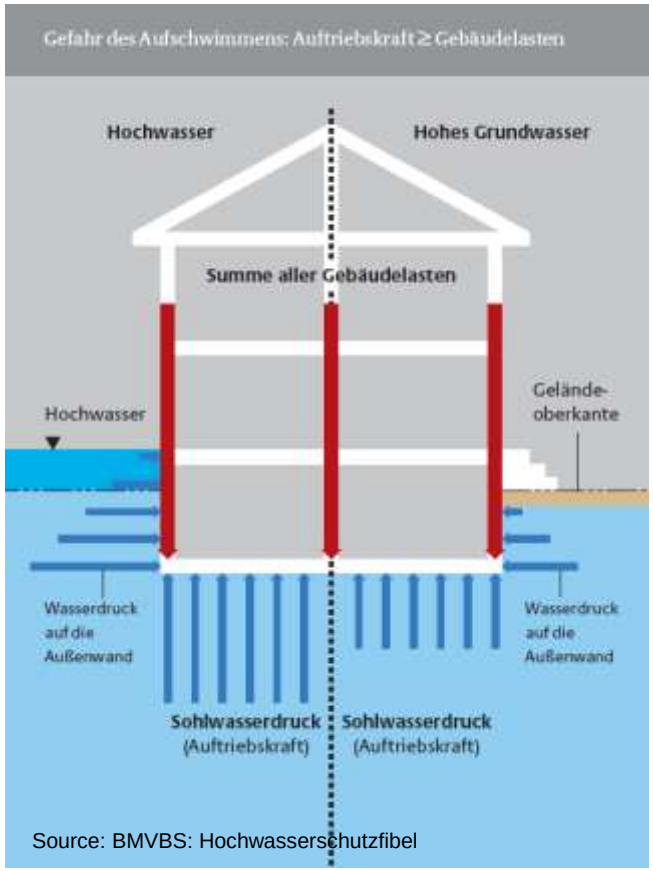
Flooding damages – why do we need to identify their types and dimension

- To determine their vulnerability and risk
- For cost/benefit estimates
- For better spatial planning
- For better preparedness
- For contingency planning
- …..

Causes: damages by example

- Parameter: water level / water pressure

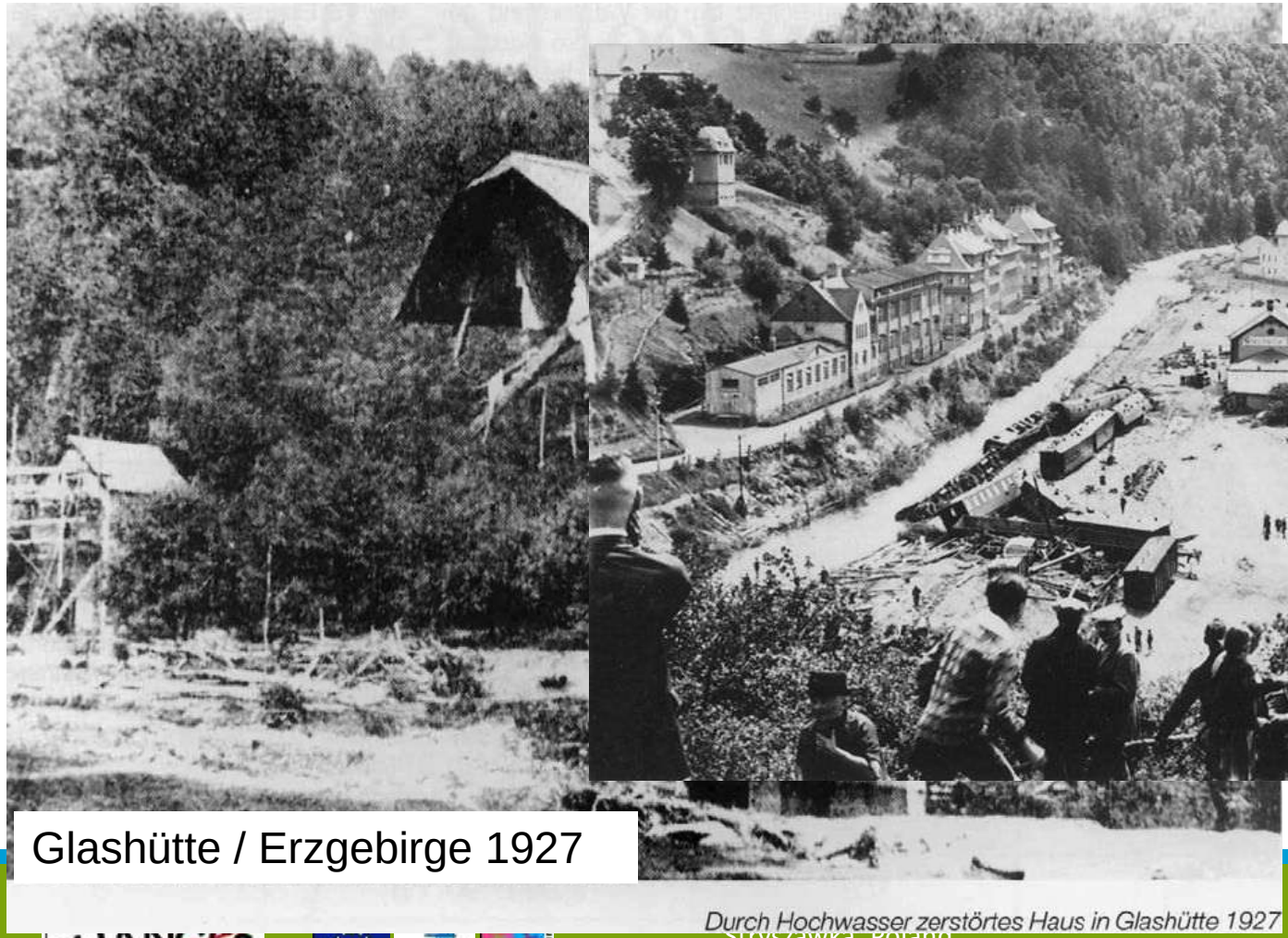
Water level / water pressure



Source: BMVBS: Hochwasserschutzfibel

Weight of building smaller than buoyant force:
-> The building will „float“
(Damages to the stability)

Parameter: flow velocity



Glashütte / Erzgebirge 1927

Durch Hochwasser zerstörtes Haus in Glashütte 1927

Population

Source: Vogt

Valuation not possible (not ethical) in terms of €

Economy

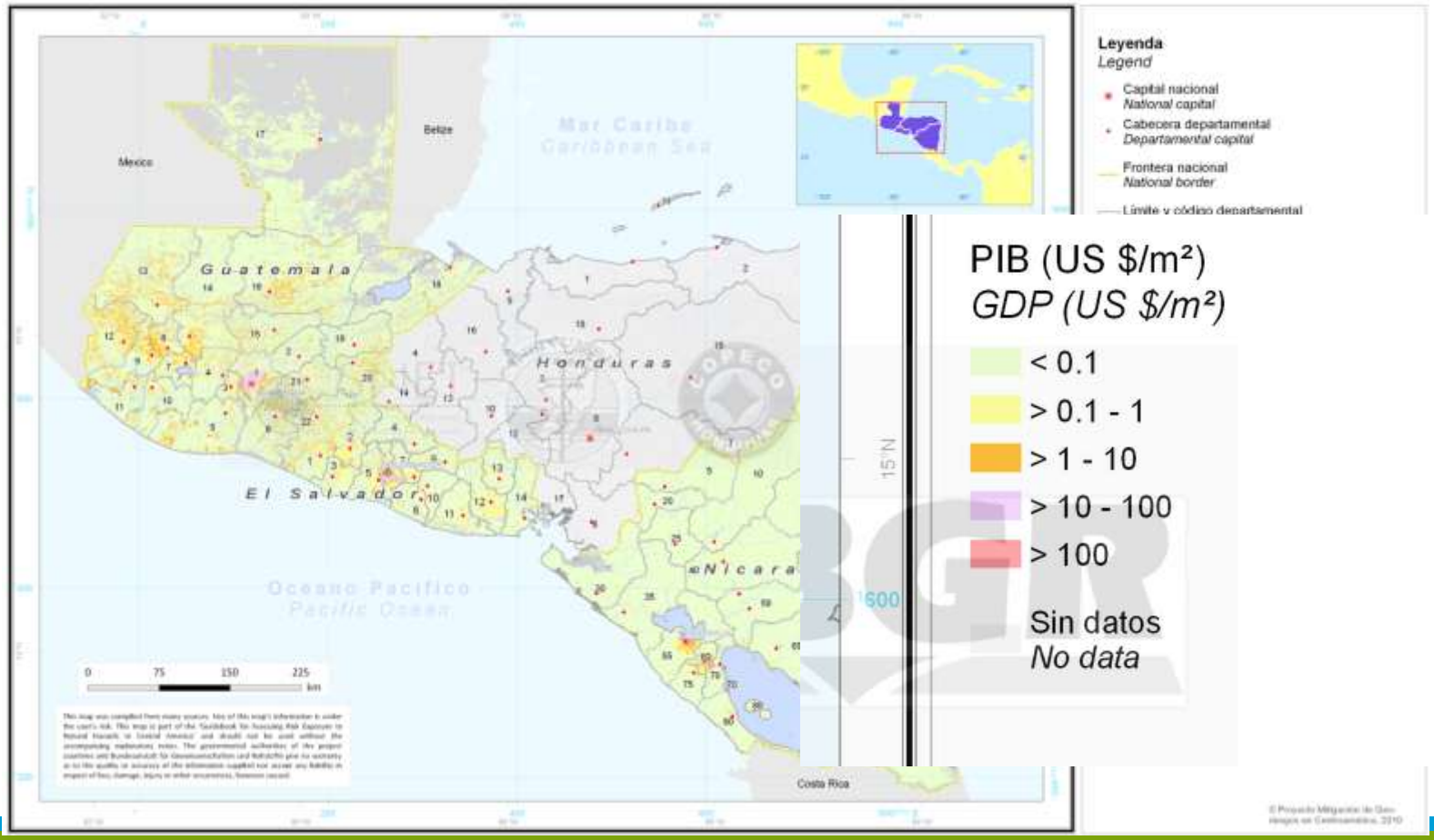
GDP Values

Country	Sector Code	Sector	GDP (US$)*	GDP (Million of National Currency)**
Nicaragua				
	1	AB Agriculture, hunting, forestry and fishing	985 083 840	21 049
	2	C Mining and quarrying	66 399 840	1 419
	3	D Manufacturing	979 917 120	20 938
	4	E Electricity, gas and water	169 673 400	3 626
	5	F Construction	320 102 640	6 840
	6	GH Wholesale and retail trade, restaurants and hotels	795 478 320	16 997
	7	I Transport, storage and communications	308 547 720	6 593
	8	JK Finance, insurance, real estate and business services	710 672 040	15 185
	9	LMNOPQ Community, social and personal services	1 094 628 600	23 390
Honduras				
	1	AB Agriculture, hunting, forestry and fishing	1 710 093 930	32 823
	2	C Mining and quarrying	155 294 470	2 981
	3	D Manufacturing	2 739 735 810	52 586
	4	E Electricity, gas and water	159 639 610	3 064
	5	F Construction	850 808 630	16 330
	6	GH Wholesale and retail trade, restaurants and hotels	2 348 558 590	45 078
	7	I Transport, storage and communications	963 474 880	18 493
	8	JK Finance, insurance, real estate and business services	2 269 455 160	43 560
	9	LMNOPQ Community, social and personal services	2 529 996 840	48 560
El Salvador				
	1	AB Agriculture, hunting, forestry and fishing	2 693 100 000	2 693

or	GDP Sector Code 8	GDP Sector Code 9
7	1	1
1	0	0
0	0	0
1	0	0
1	0	0

Potencial Económico

Economic Potential



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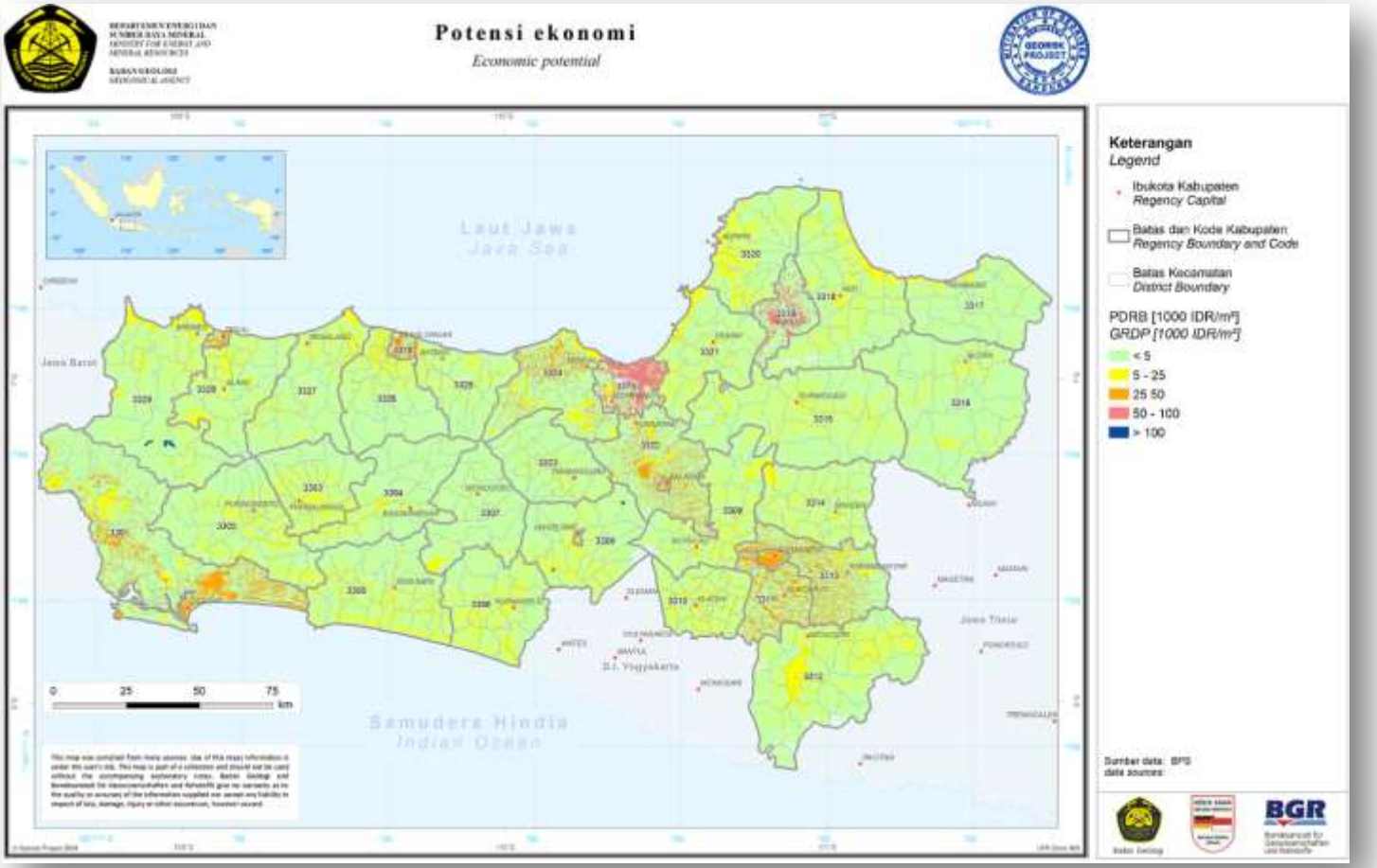

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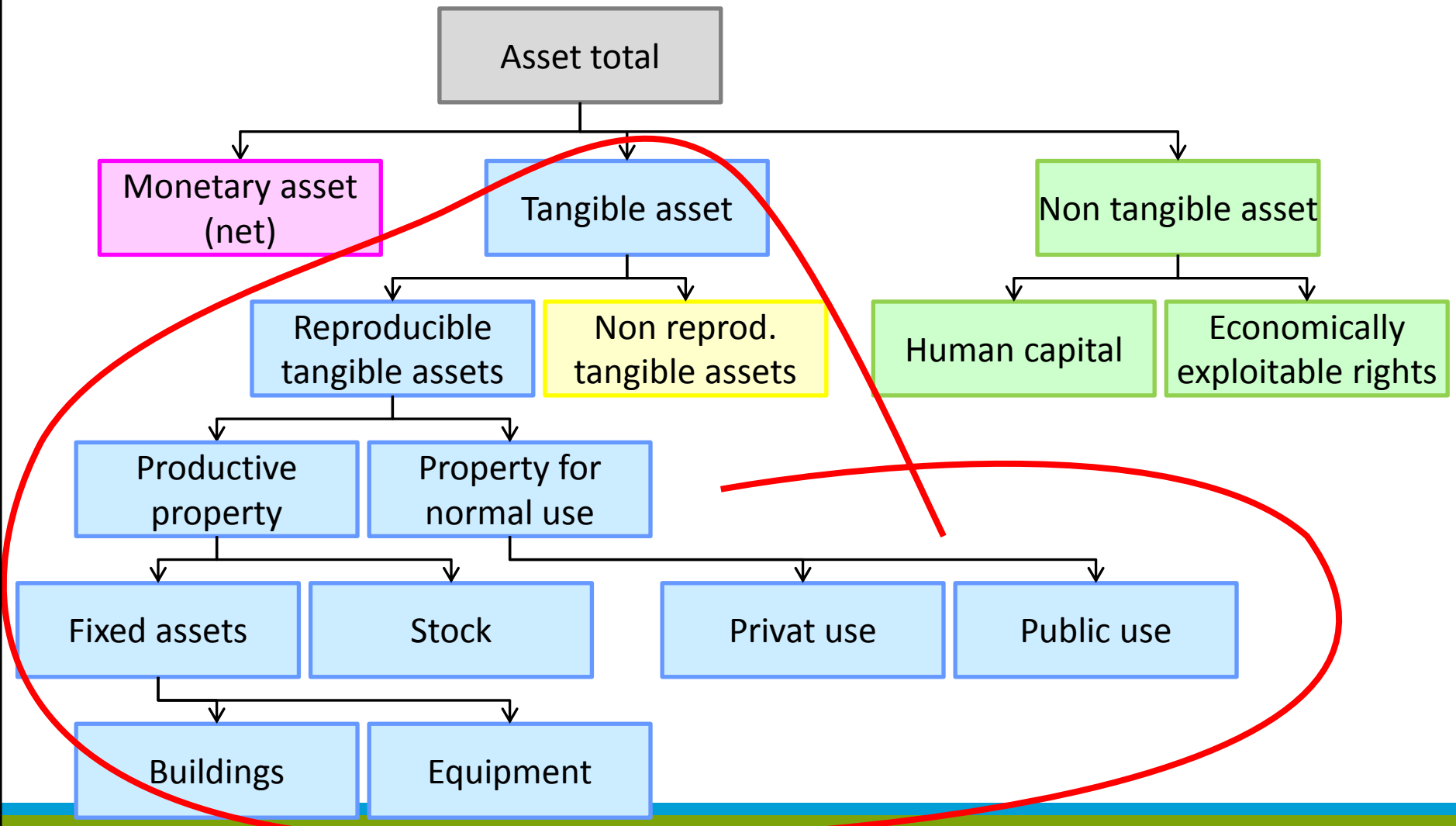
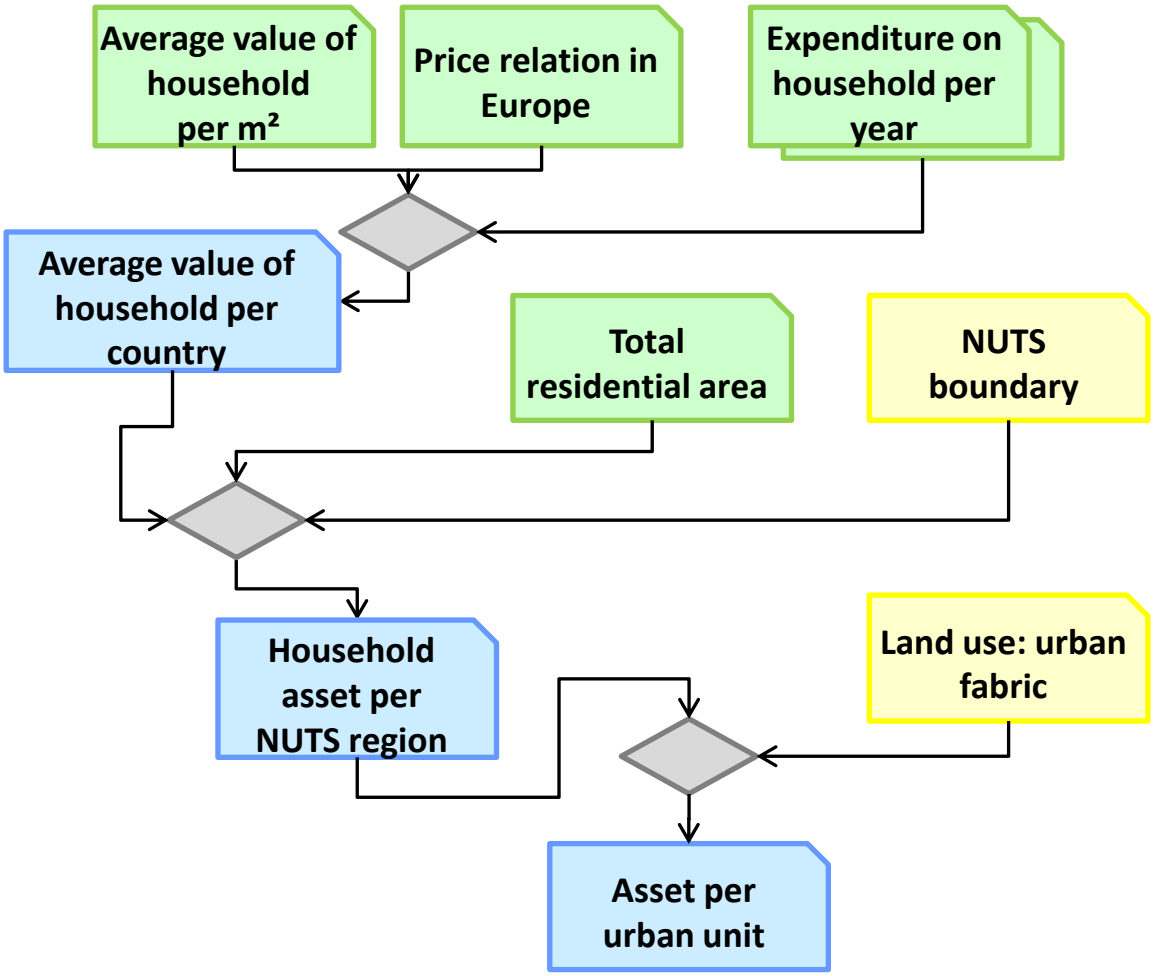
Structure of asset terminology

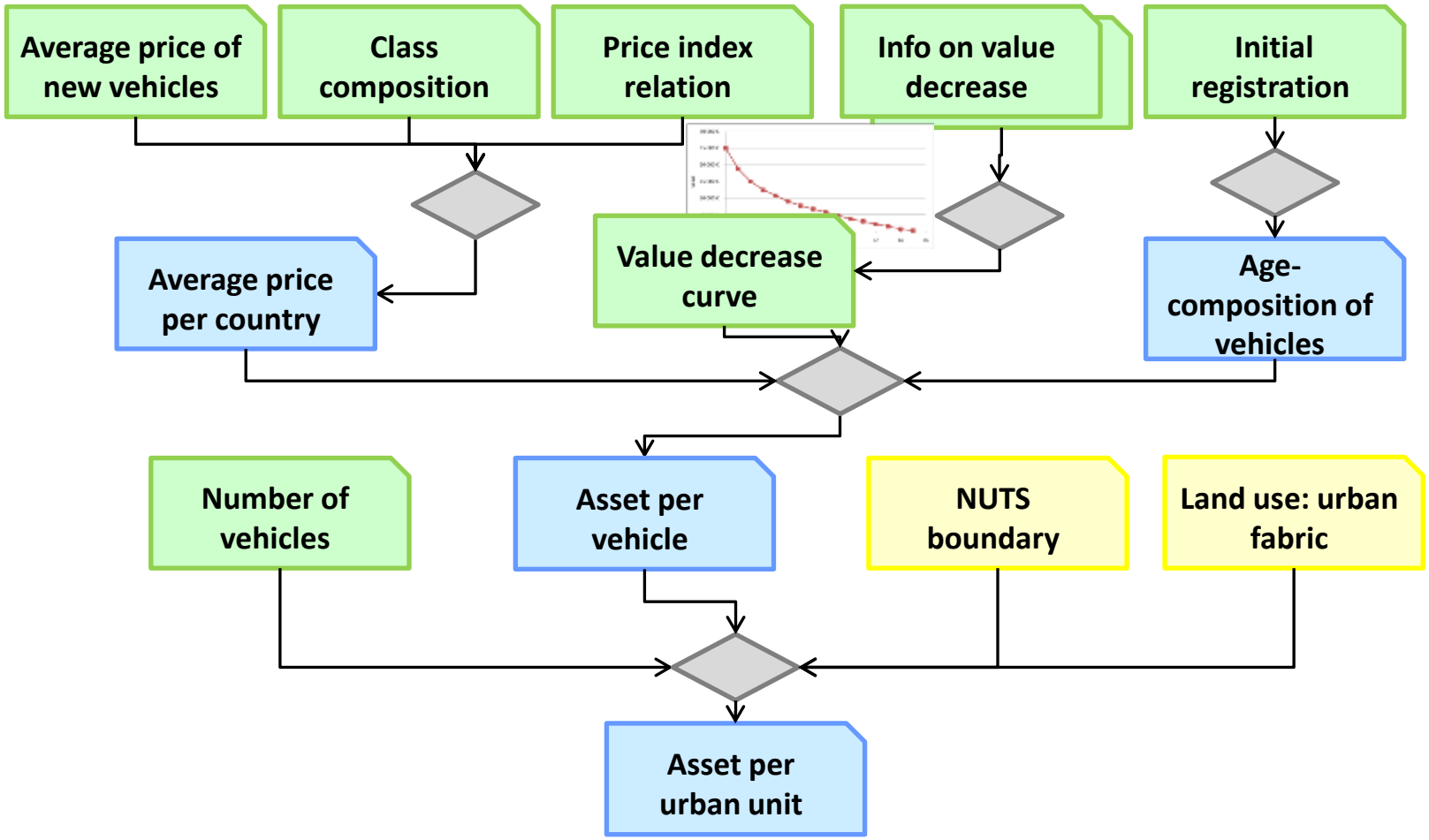


Source: M. Frenkel & K.D. John, 1999 (modified)

Asset: Household goods



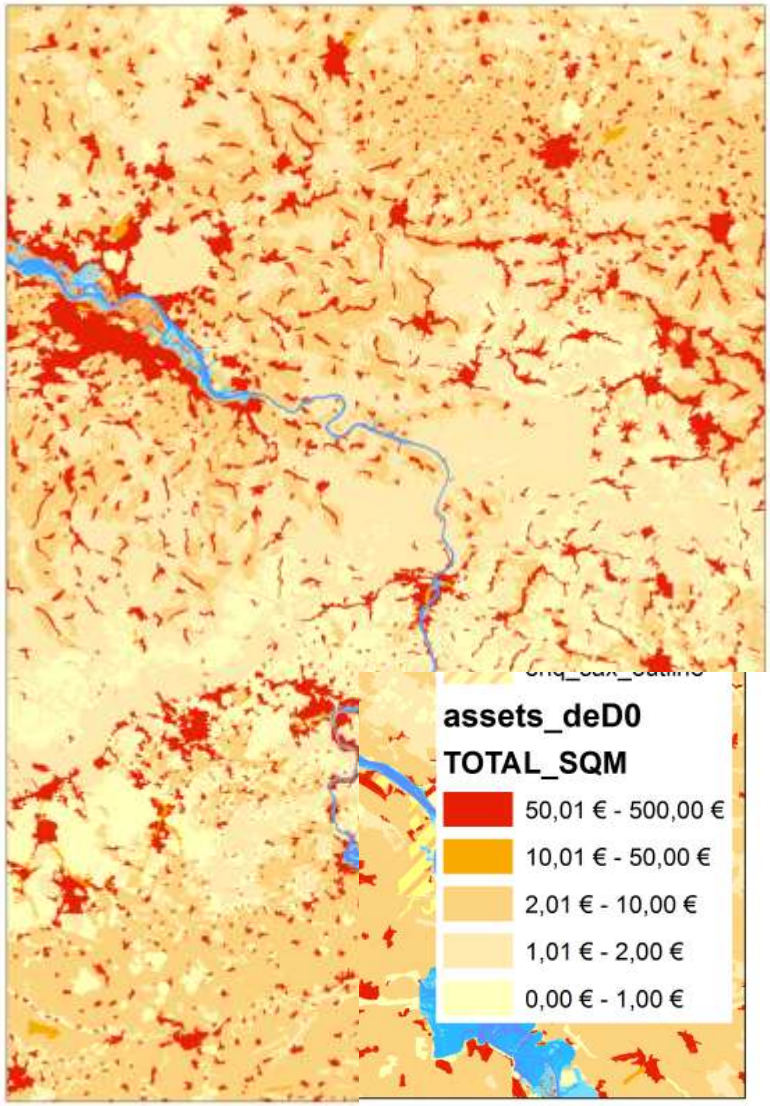
Asset: Vehicles



Example BEAM

Basic European Assest Map

(regional to national scale)



CHANGES Risk=HVA

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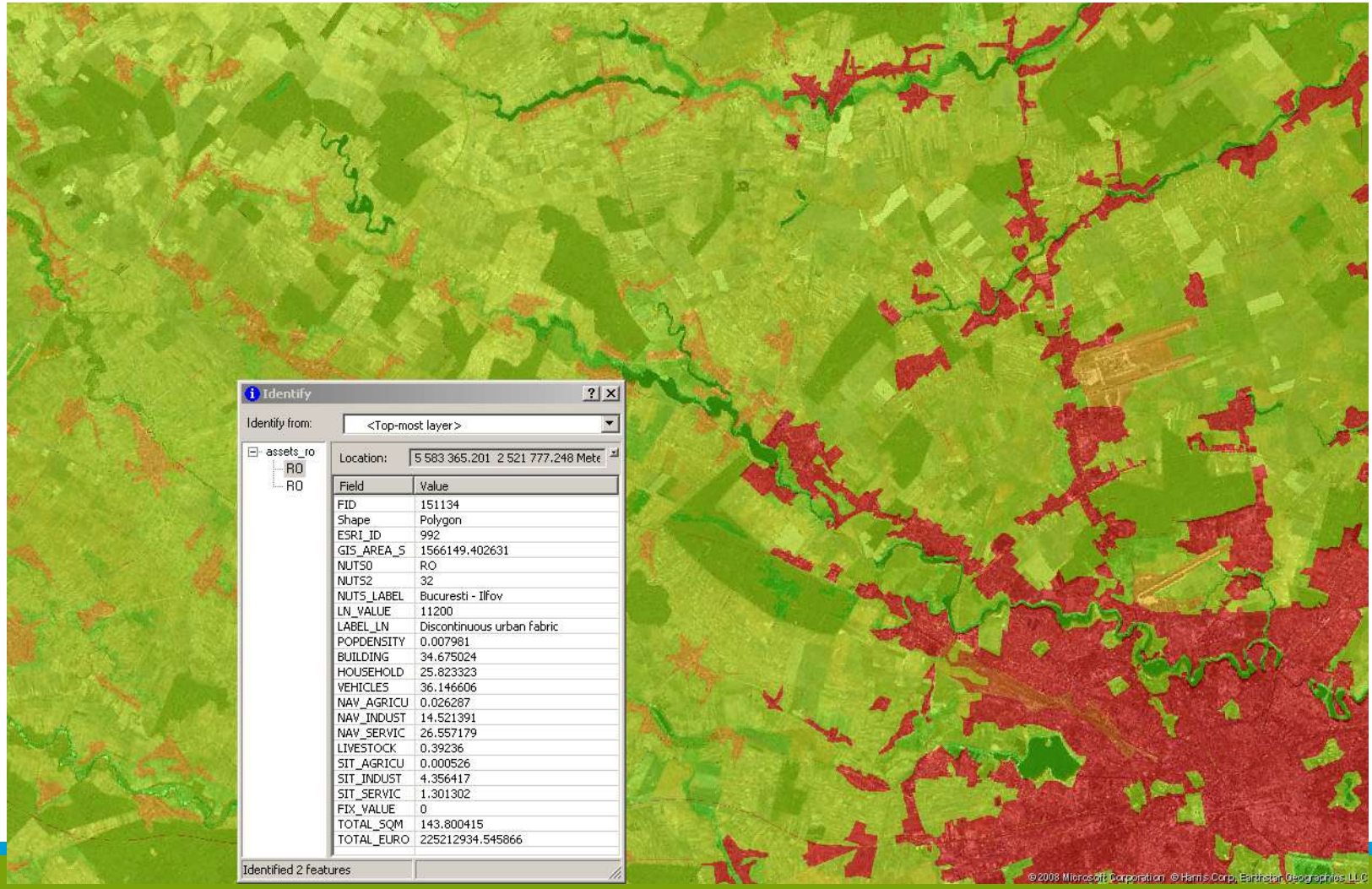
BEAM product example Bucharest

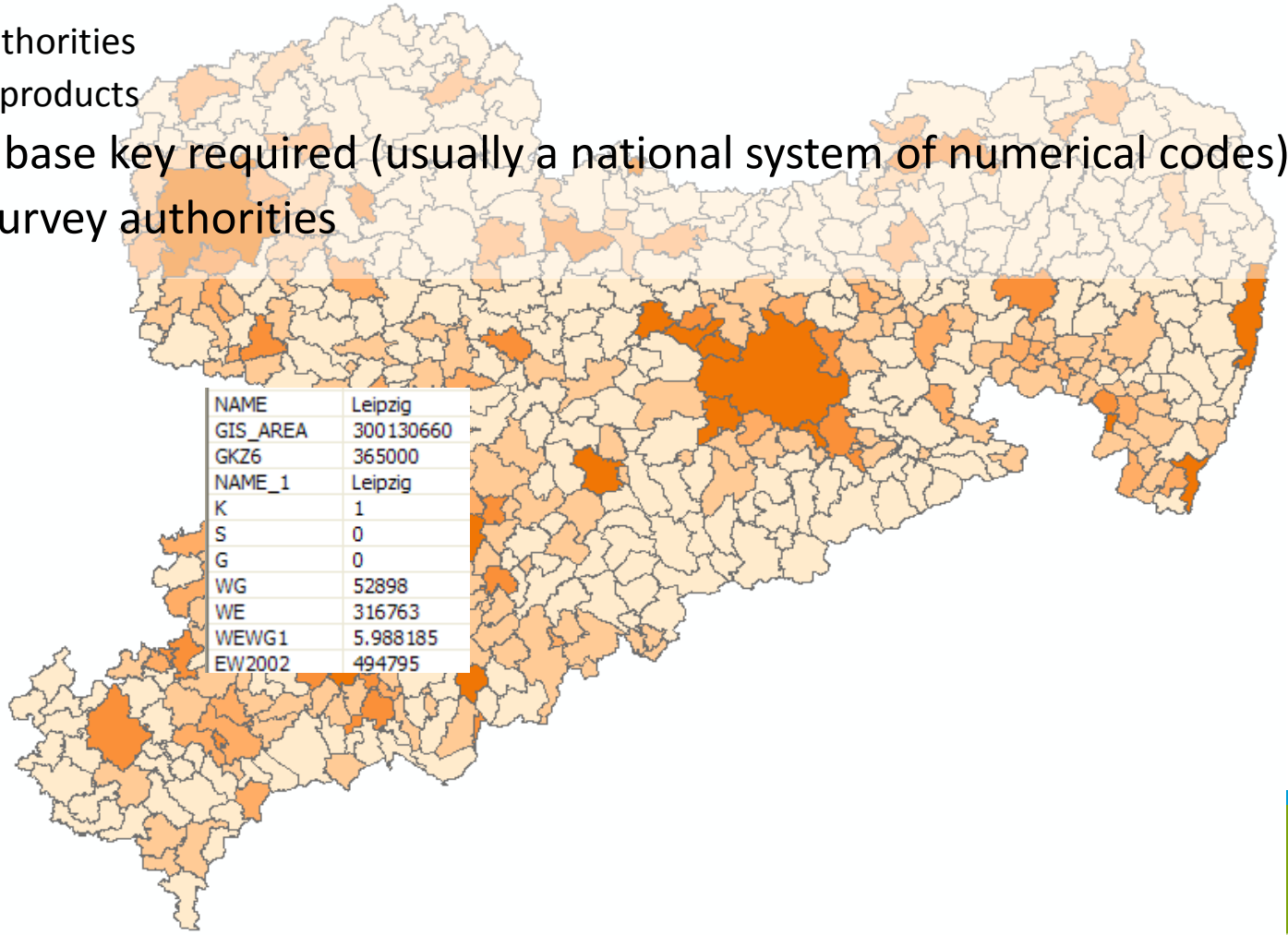


Calculation of potential damage / EAR:

- Procedure for <u>population</u> at risk
  - Required input data
    - Information on demographics
    - Information on administrative (sub)-division of the study area
    - Information on land use / land cover
    - Flood hazard map (inundation areas), perhaps with different probabaility of flooding (2yr, 5yr, 10yr, 100yr-flood etc.)
  - GIS based intersection
  - Result: count (better: statistical estimate) of potentially affected population per administrative sub-division (national, sub-national, province, county, city, etc.)

Administrative Gliederung & Demographische Daten

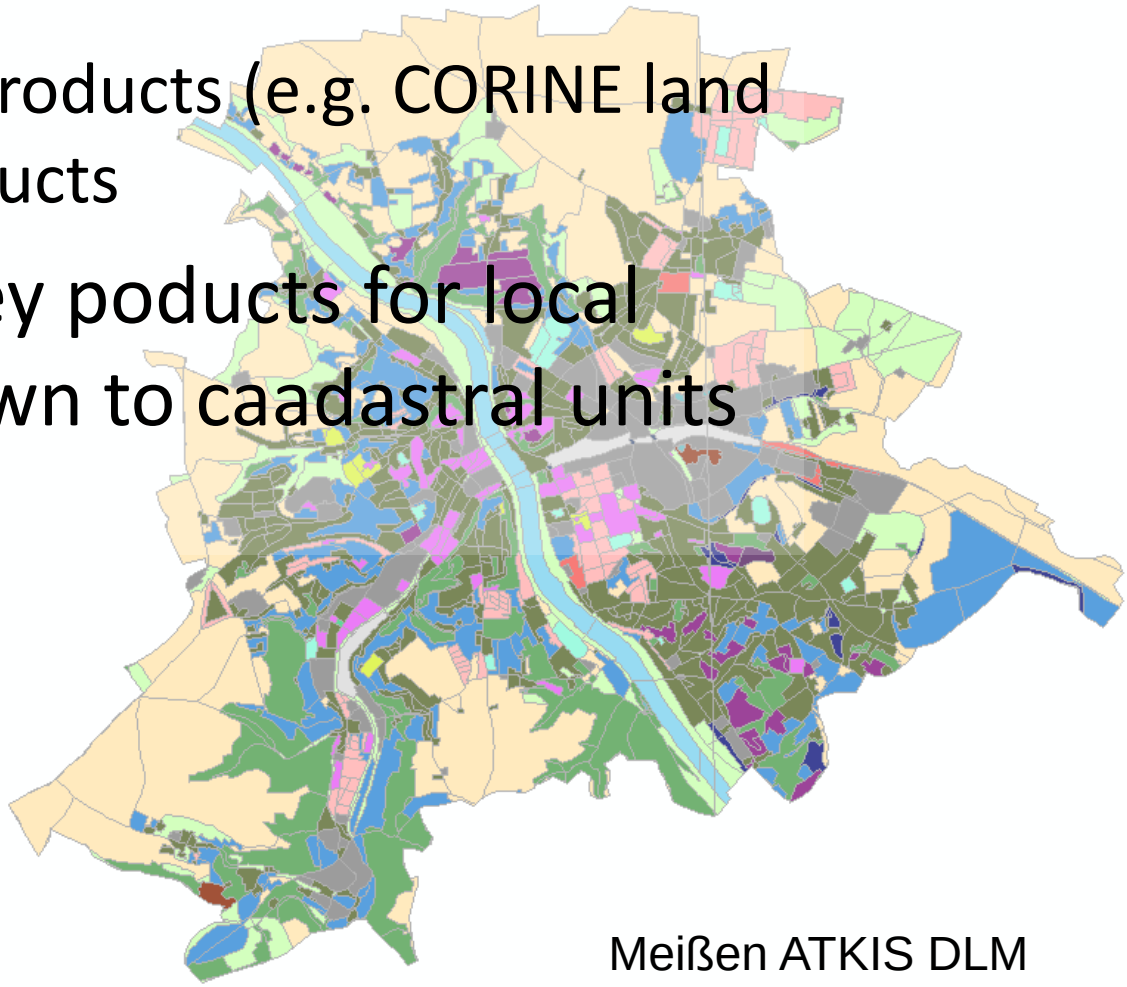
- Data sources:
  - Statitstics authorities
  - Commercial products
- Common database key required (usually a national system of numerical codes)
- Topographic survey authorities



NAME	Leipzig
GIS_AREA	300130660
GKZ6	365000
NAME_1	Leipzig
K	1
S	0
G	0
WG	52898
WE	316763
WEWG1	5.988185
EW2002	494795

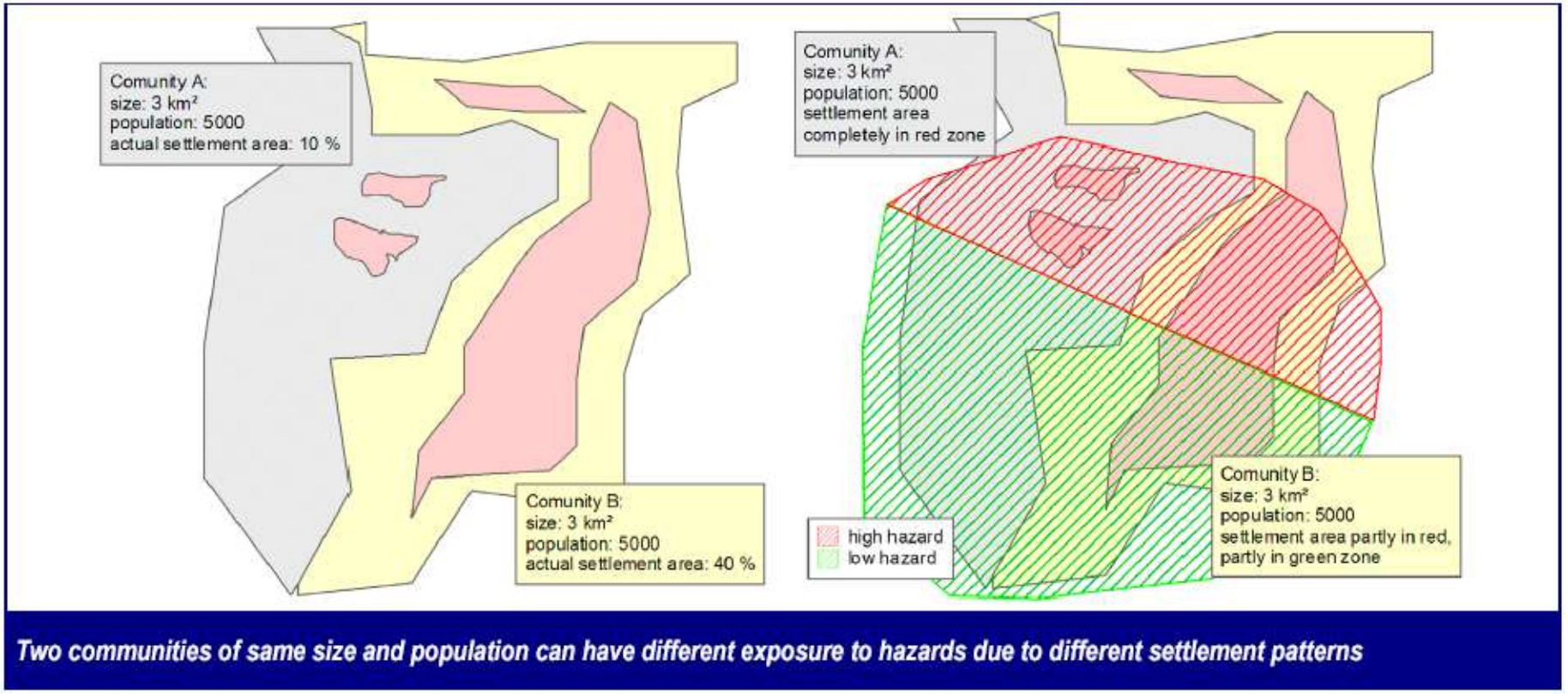
Land use / land cover

- Data sources:
  - Remote sensing products (e.g. CORINE land cover, GMES products
- Topographic survey poducts for local scale, perhaps down to caadastral units



Meißen ATKIS DLM

Schematic Dipiction of exposure assessment

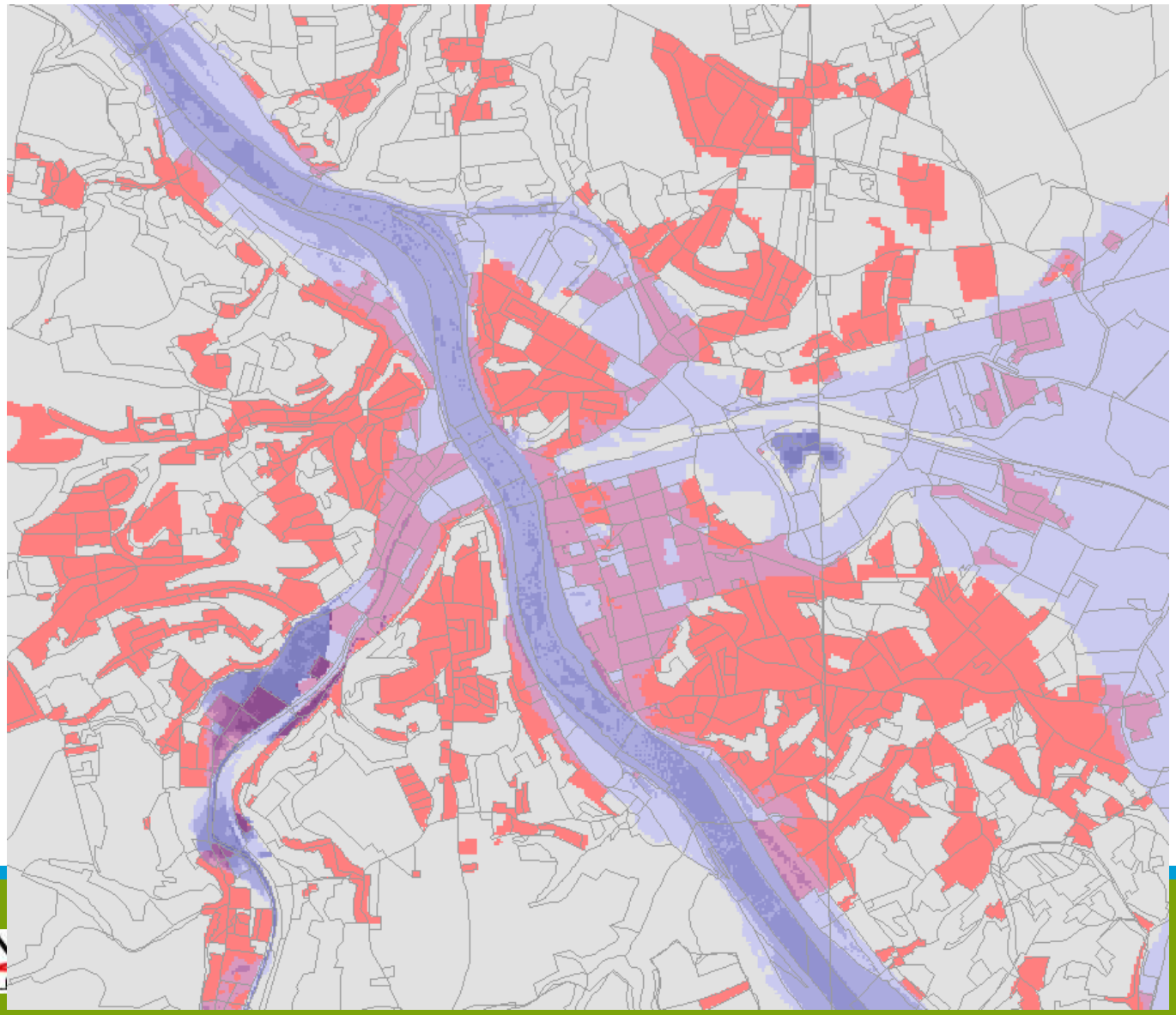


Two communities of same size and population can have different exposure to hazards due to different settlement patterns

Approach

- Procedural Steps:
  - Calculation of population density – on residential / settlemen) areas only!
  - GIS intersection of inundation area (classes) and settlement areas
  - Summarize

- Example City of Meißen:
  - Population: 28780 (2002)
  - Total area: 30,7 km²
  - Population density “raw”: 937 persons / km²
  - Total settlement area: (ATKIS): 6,8 km²
  - Population density “modified”: 4230 / km²!



Calculation Example

- Meißen:
  - Settlement area: 6.8 km²
  - Of this area affected by flooding 1.56 km²
  - Portion: ca. 23%
- -> potentialy affected by flooding:

  Modified density * affected area = 4230 * 1.56 = rd. 6 600 Pers.

  alternativ: 23 % of the total population: 23/100 * 28780 = rd. 6 600 Pers.

Berechnung betroffene/gefährdete Personen

Tabelle 5: Betroffene und davon gefährdeten Personen (in Tausend) Sachsen

Ein		davon gefährdete
Elbe		
Ege		
Mul		
Wei		
Spr		
Nei		

Tabelle 2: Möglicherweise betroffene Personen Rhein

Rheinabschnitt	Betroffene Personen	davon Gefährdete Personen
	auf Überschwemmungs-flächen	ab Wassertiefe > 200 cm
Hochrhein	7.400	100
Oberrhein	777.400	322.400
Mittelrhein	73.300	45.200
Niederrhein	1.264.200	557.400
Rheindelta	8.564.000	4.576.900
Summe	10.686.300	5.502.000

Calculation of potential damage:

- Procedure for direct economic damages
- Required data
  - Information on assets, generalized or detailed
  - Information on land use
    - Information on land use / land cover
    - Flood hazard map (inundation areas), perhaps with different probability of flooding (2yr, 5yr, 10yr, 100yr-flood etc.)
- Damage function (vulnerability curves…)
- Methods can be based on an area approach or on an object approach

Damage functions

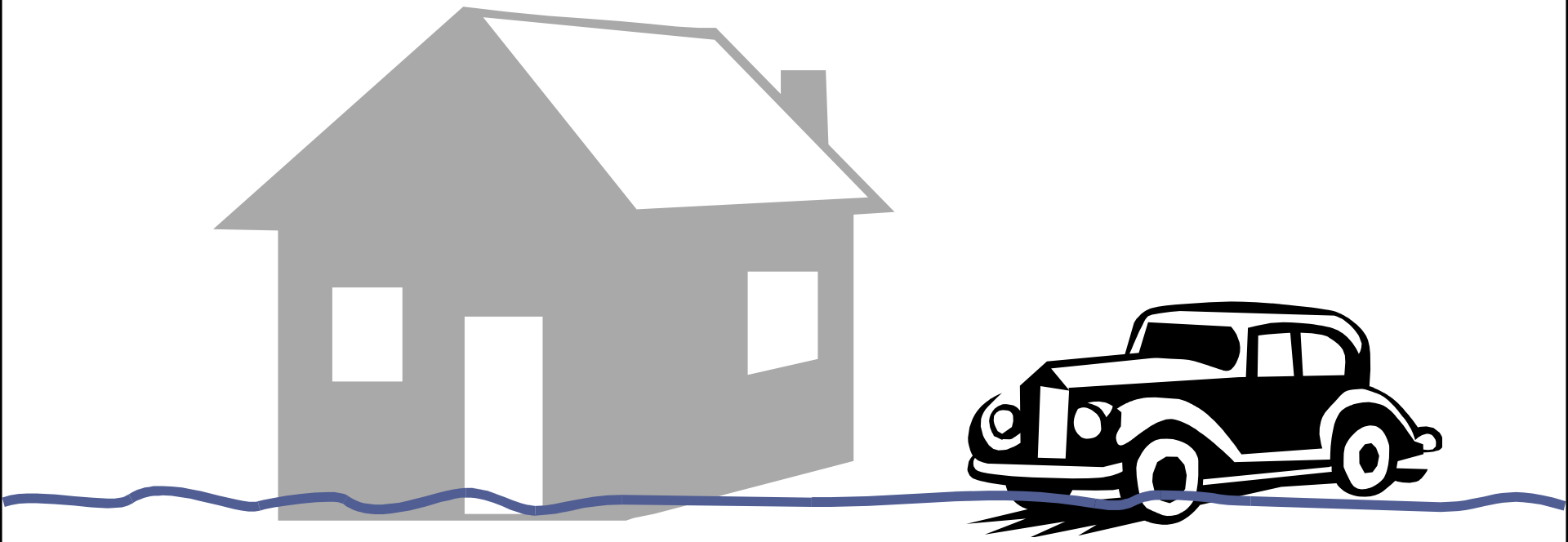
- Grade of damage in relation to intensity of a hazard
- Intensity can be determined by:
  - Inundation depth
  - Flow velocity
  - …
- Mainly empirical functions

Damage functions

- Must be considered in relation to the land use and asset data set on which they are applied
- Also can be influenced by additional parameters:
  - Warning time
  - Duration of flooding
  - Age of building
  - Flood protection measures

Calculation of damage potentials

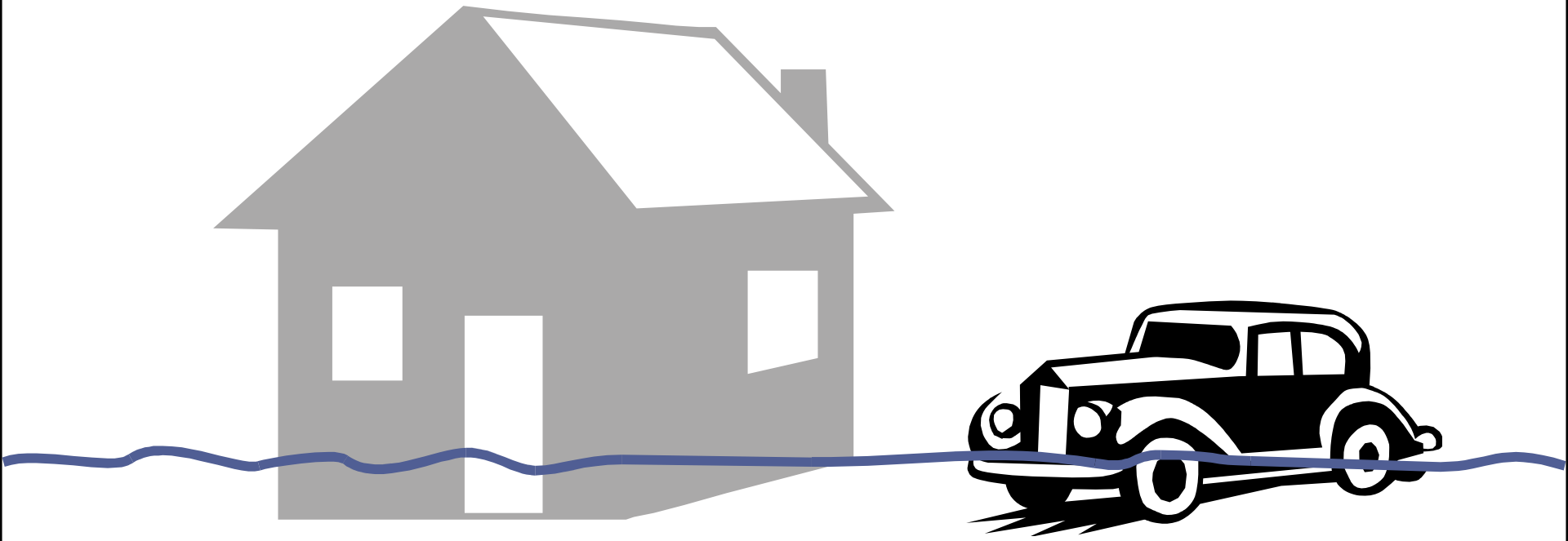
- Usually no damage
- No damage



Inundated areas

Calculation of damage potentials

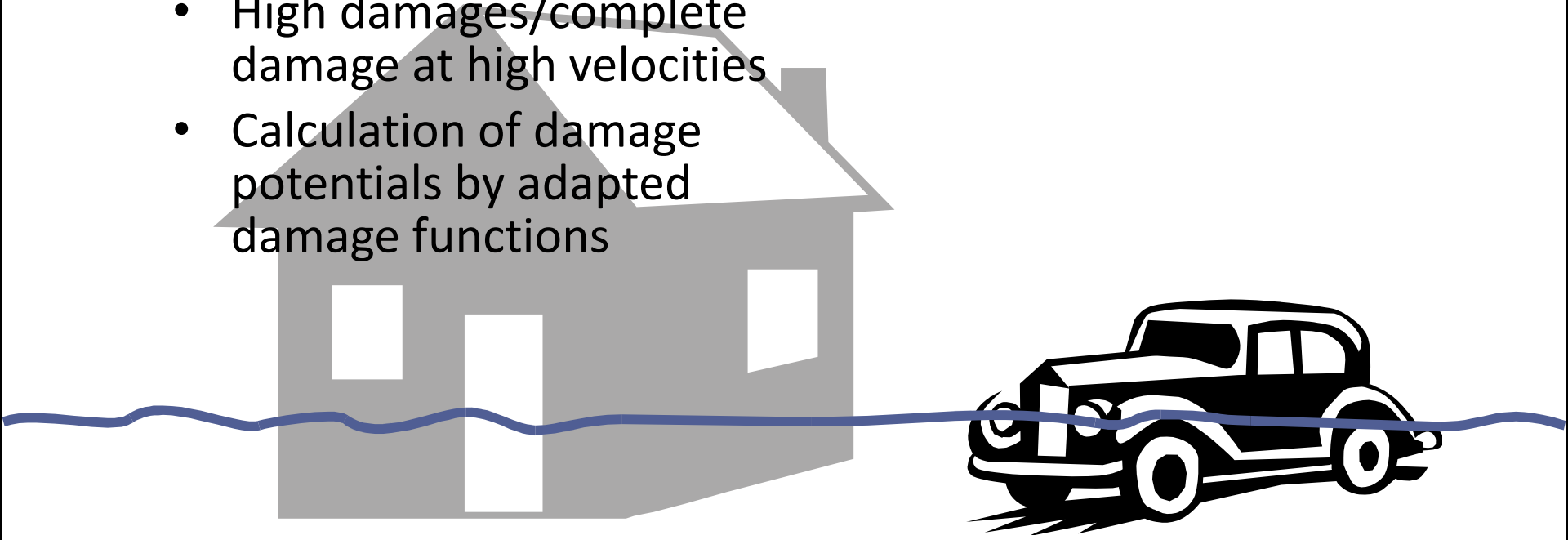
- No or small damage at low flow velocities
- No damage at low velocities



Calculation of damage potentials

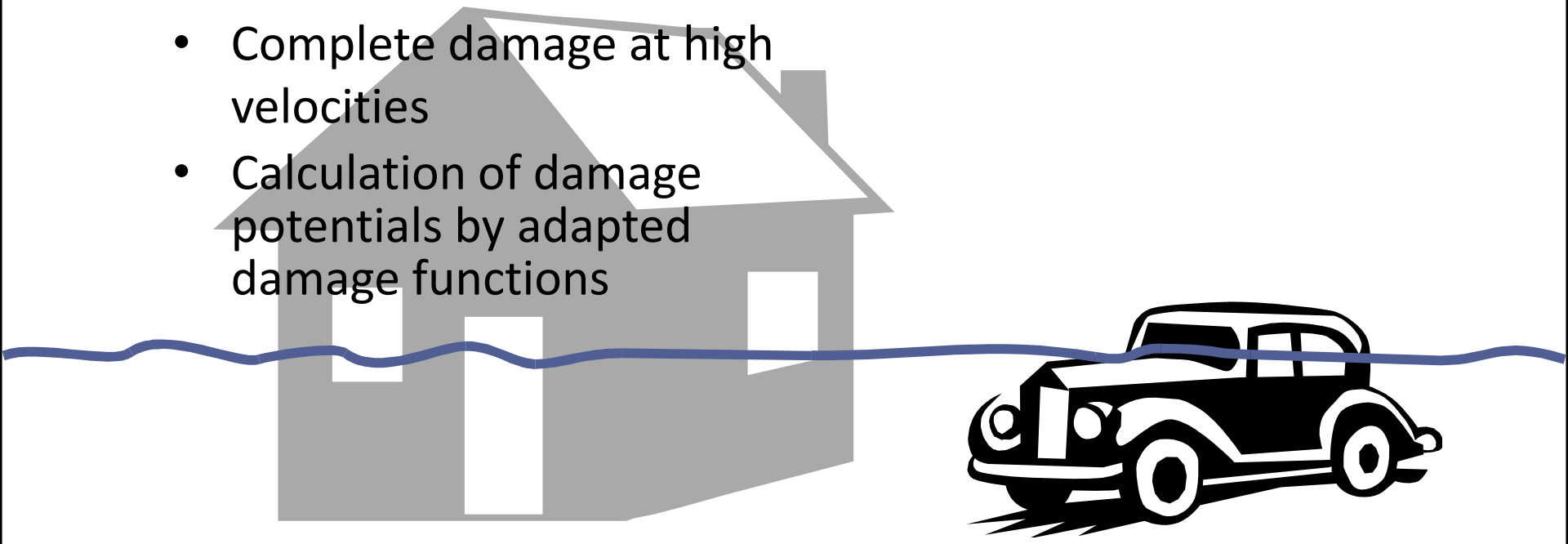
- Low damages at low velocities
- High damages/complete damage at high velocities
- Calculation of damage potentials by adapted damage functions

- Potential complete damage



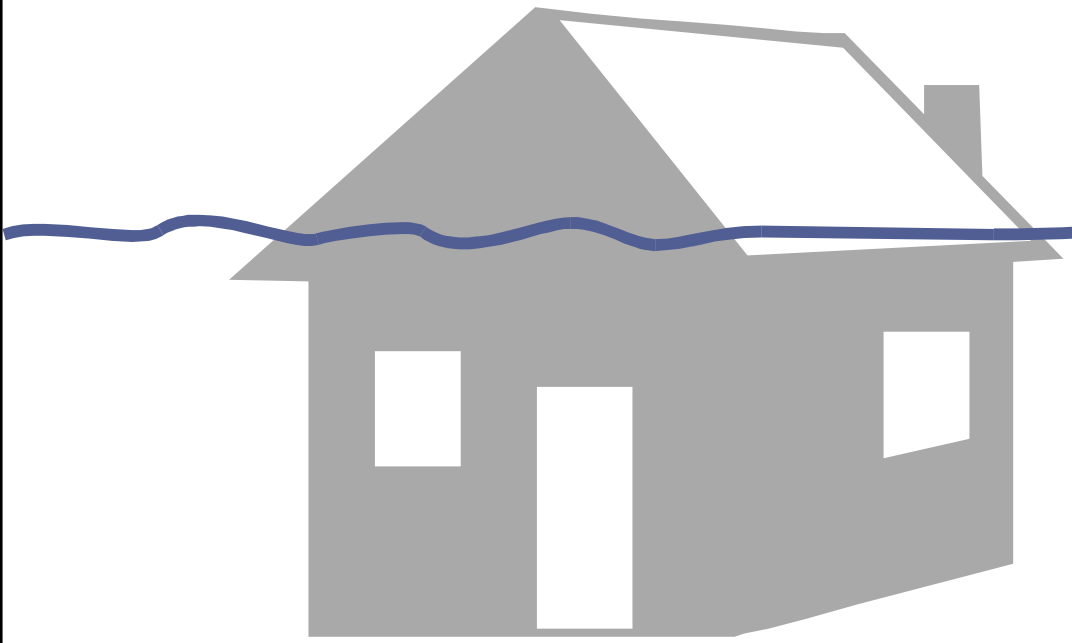
Calculation of damage potentials

- Low to moderate damages at low velocities
- Complete damage at high velocities
- Calculation of damage potentials by adapted damage functions
- Complete loss

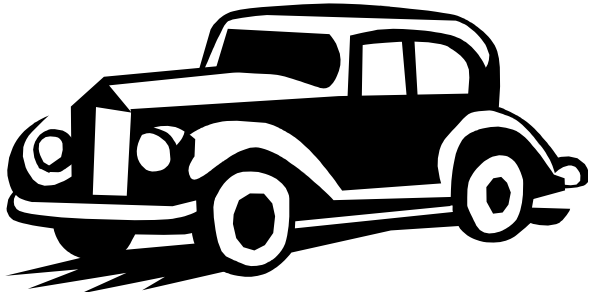


Calculation of damage potentials

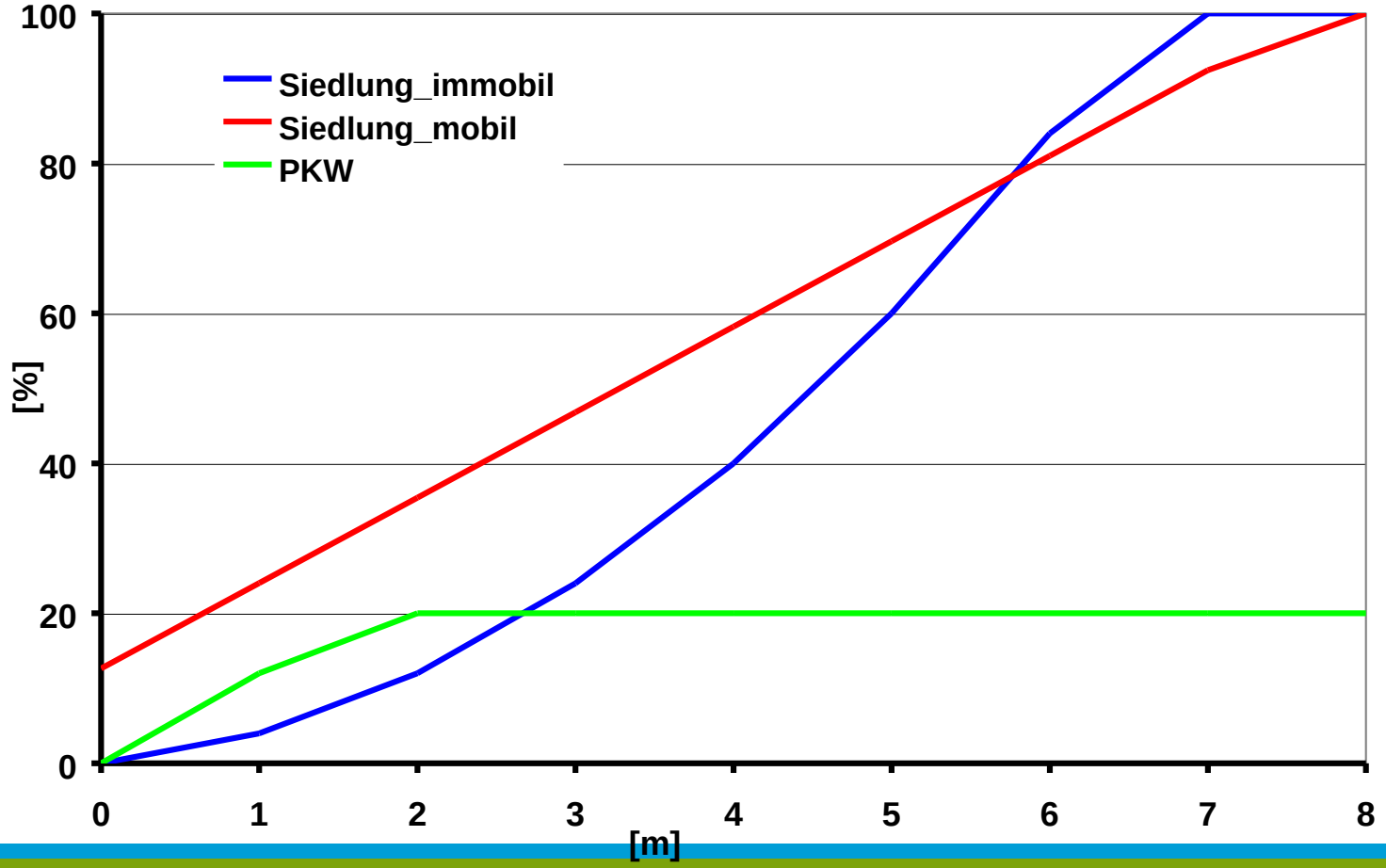
- Complete loss



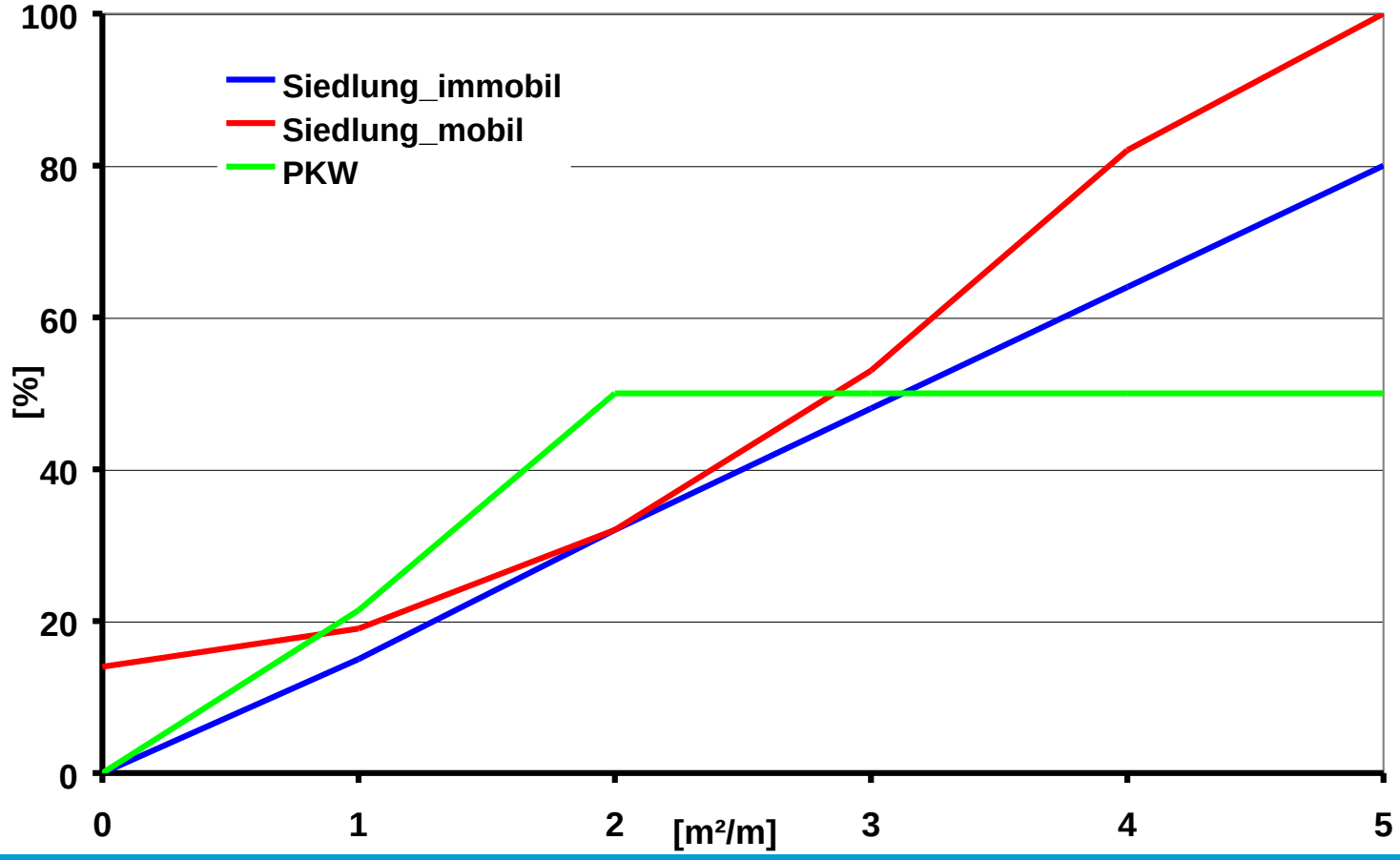
- Complete loss



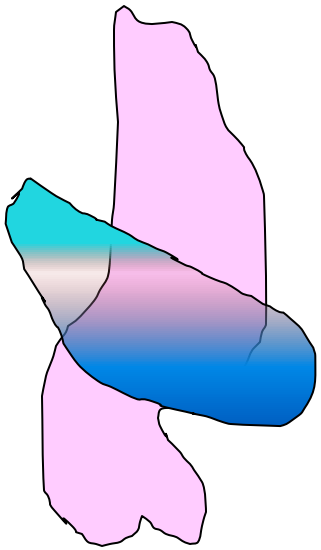
Damage functions - lowland rivers



Damage functions - steep terrain rivers

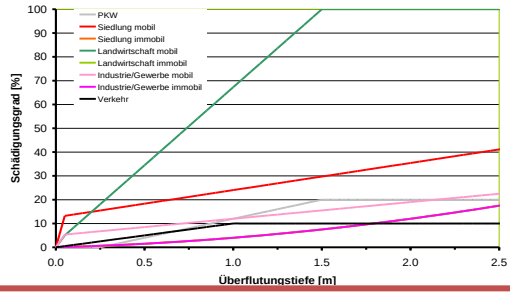


Application in GIS



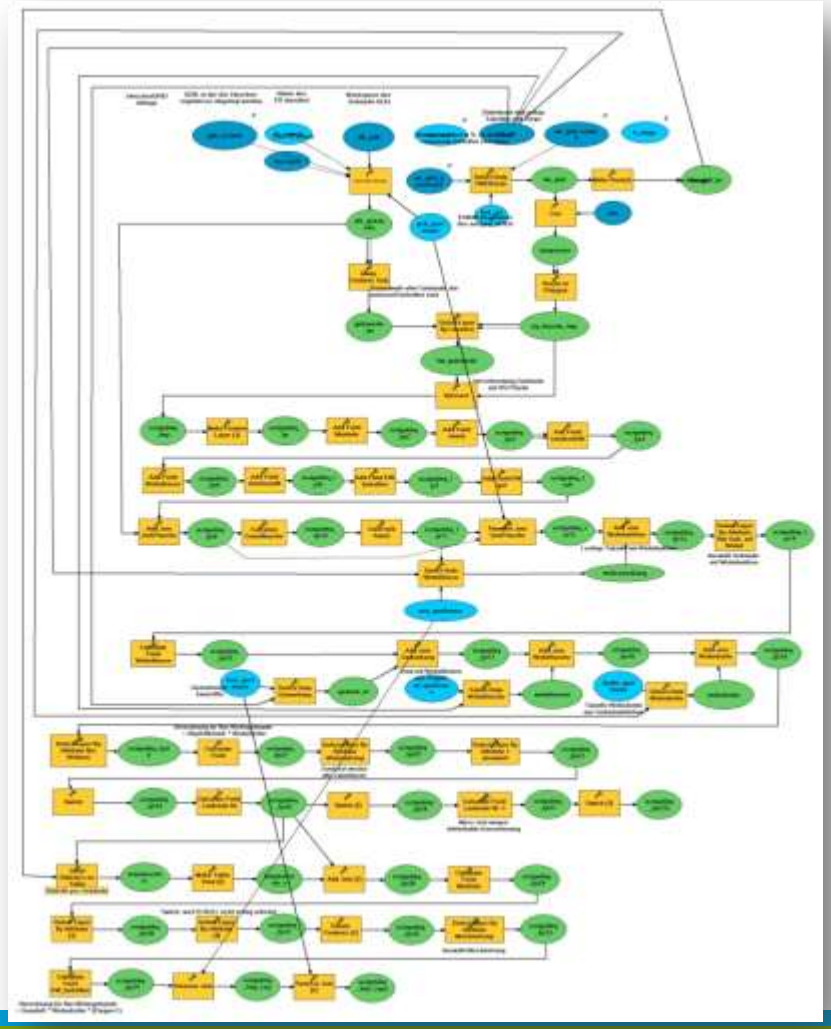
- Discontinous Urban Fabric
  - Size: 150 000 m²
  - NUTS2: Castilla-La Mancha
  - Size of the hazard area: 75 000 m²
  - Building Asset (privat): 37.81 €/m²
  - Houshold asset (privat): 23.2 €/m²
  - Exposed Asset:
    75 000 m² * 37.81 €/m² => 2 835 750 €
  - Exposure household assets:
    75 000 m² * 23.2 €/m² => 1 740 000 €
  - DF buildings: 10% => 283 575 €
  - DF household: 25% => 435 000 €
  - Potential Damage: 718 575 €
    for this scenario

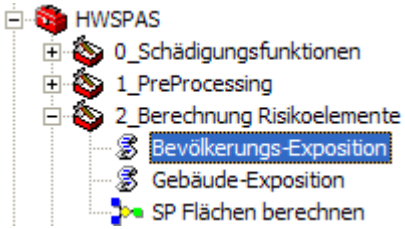
Damage functions



Relation between water depth and rate of damage
Needs to be adjusted to each land use data set

GIS Models



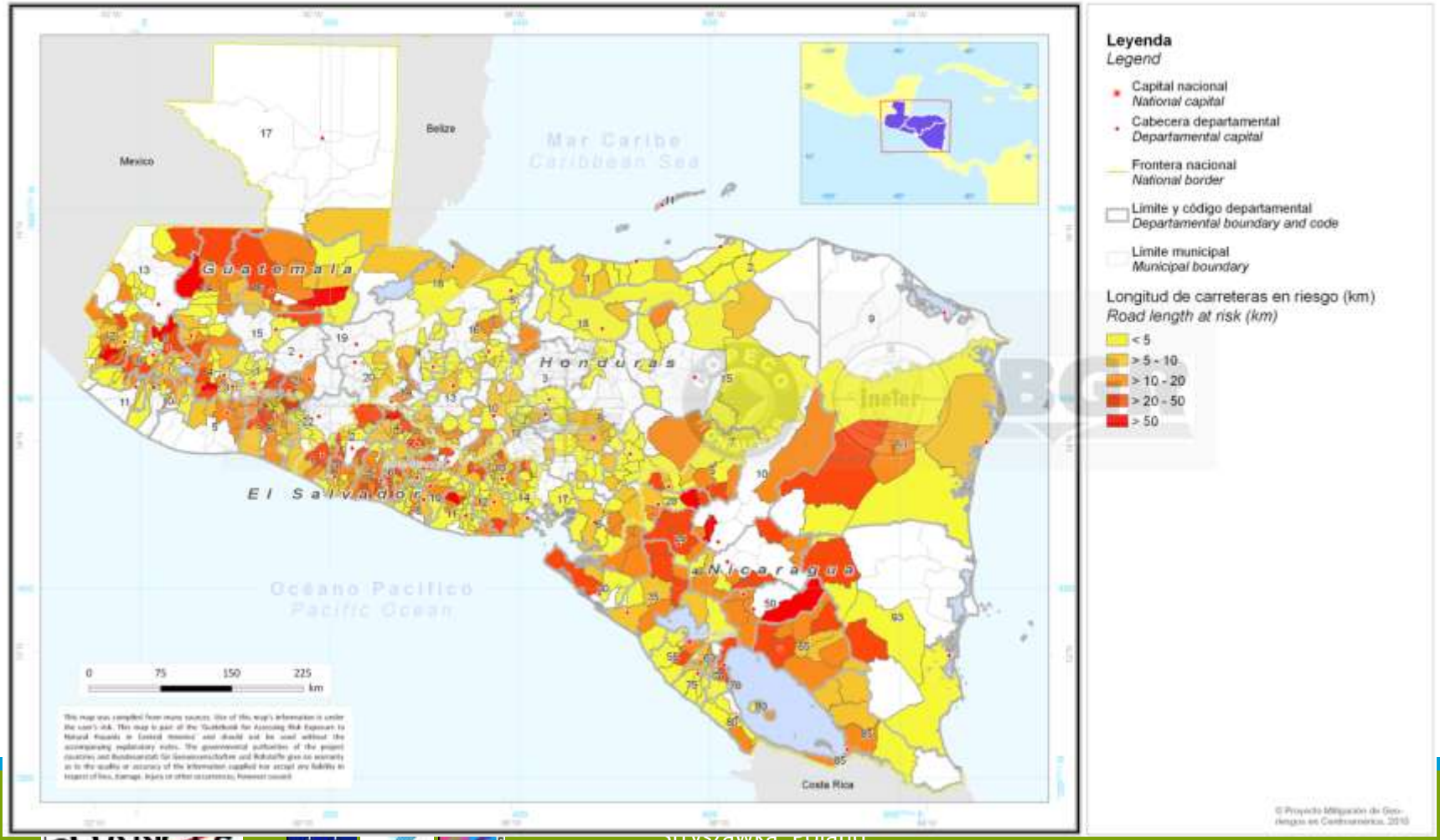

HWSPAS
0_Schädigungsfunktionen
1_PreProcessing
2_Berechnung Risikoelemente
Bevölkerungs-Exposition
Gebäude-Exposition
SP Flächen berechnen

Products for Stakeholders

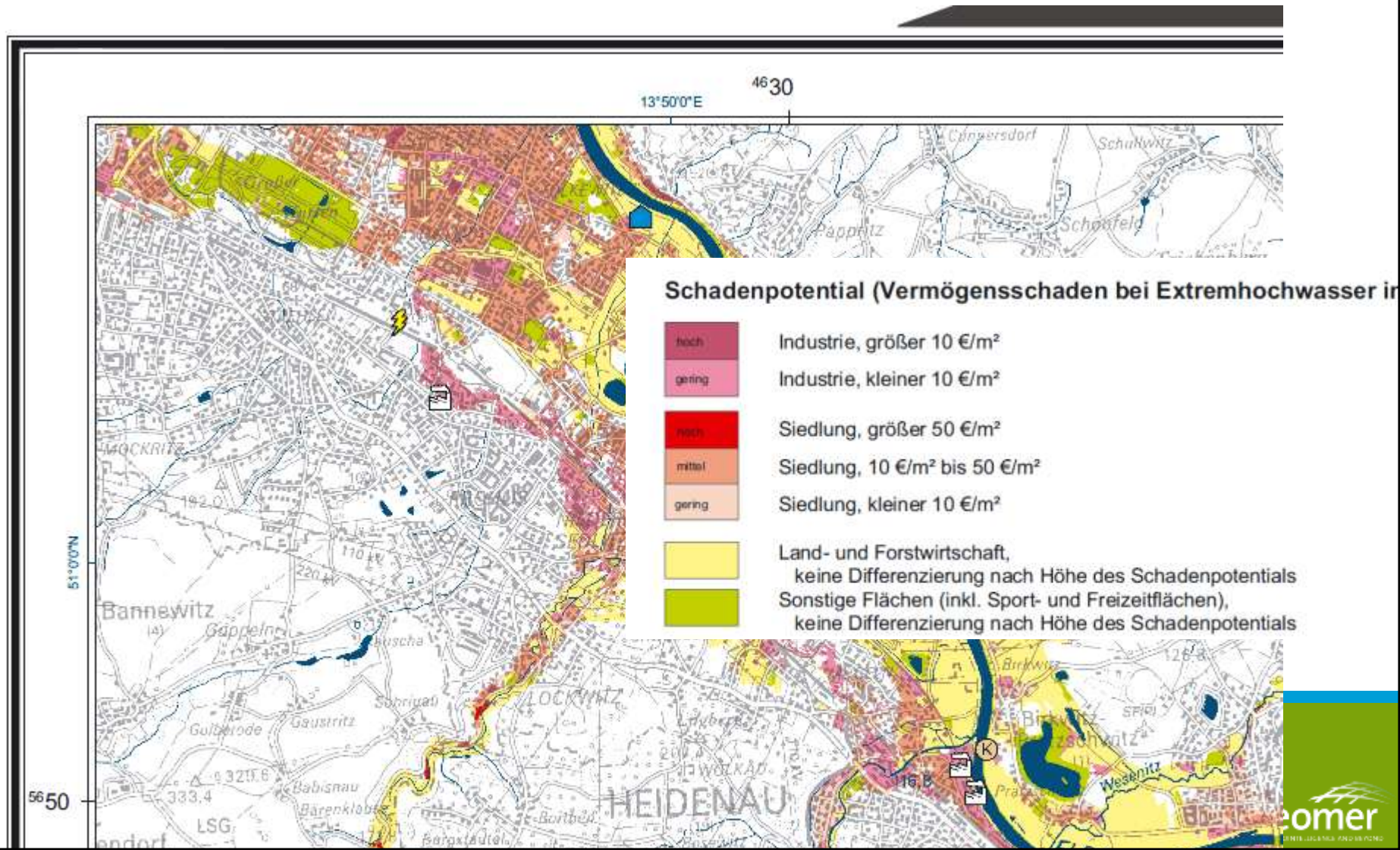
National

Longitud Total de Carreteras Principales Expuestas a Deslizamientos (Susceptibilidad Alta - Muy Alta)

Total Length of Major Roads Exposed to High and Very High Landlide Susceptibility

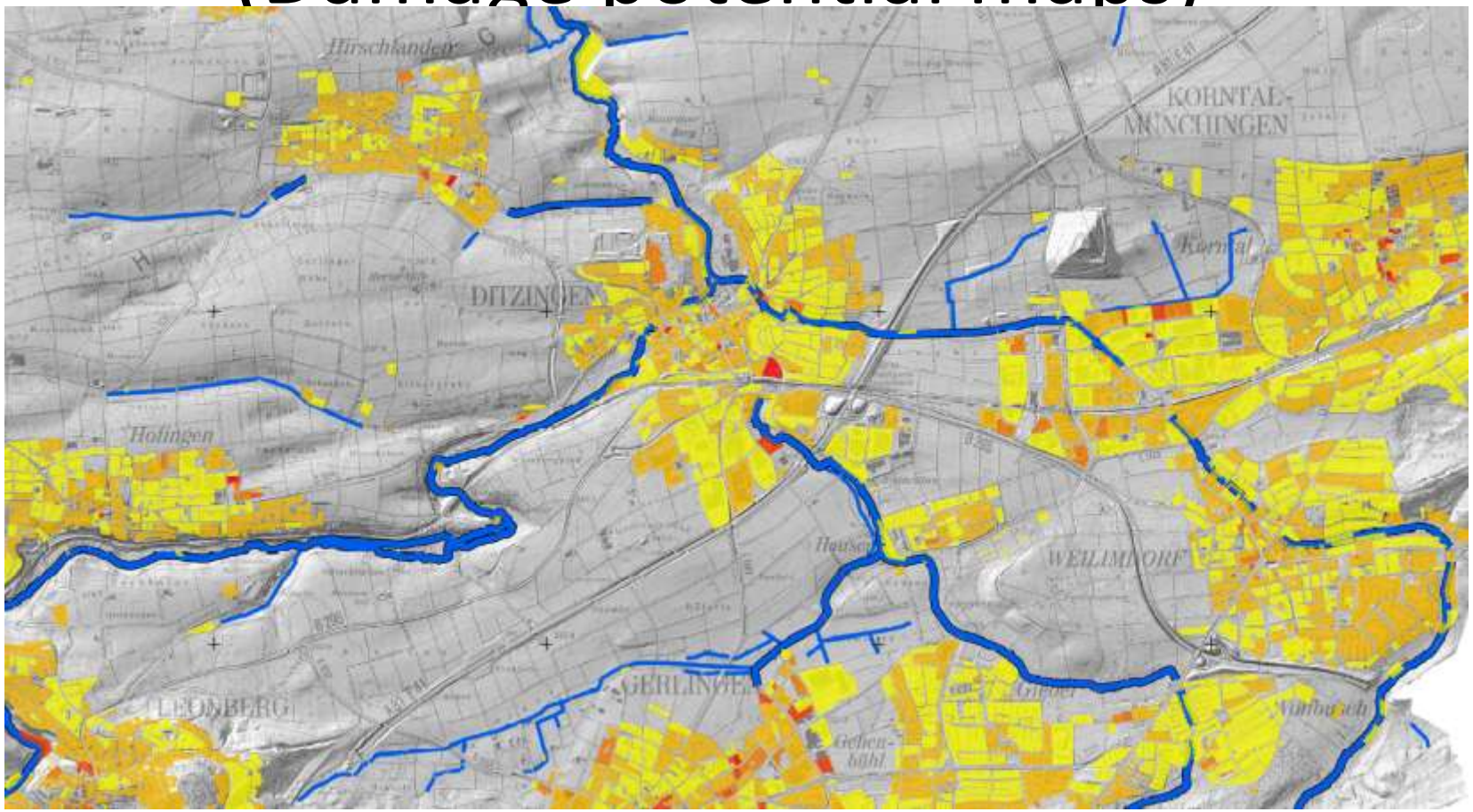


Regional



13°50'0"E
4630
5650
51°0'0"N
Schadenpotential (Vermögensschaden bei Extremhochwasser in
hoch
Industrie, größer 10 €/m²
gering
Industrie, kleiner 10 €/m²
hoch
Siedlung, größer 50 €/m²
mittel
Siedlung, 10 €/m² bis 50 €/m²
gering
Siedlung, kleiner 10 €/m²
Land- und Forstwirtschaft,
keine Differenzierung nach Höhe des Schadenpotentials
Sonstige Flächen (inkl. Sport- und Freizeitflächen),
keine Differenzierung nach Höhe des Schadenpotentials
Bannewitz
HEIDENAU
Wesenitz

Local
(Damage potential maps)



Kartenbezeichnung:

Schadenpotenzial

Häufiges bis mittleres Niederschlagsereignis (ca

Legende:

Spezifisches Schadenpotenz

(Aggregierung per Baublock)

- < 10€/m²
- 10 - 50€/m²
- 50 - 100€/m²
- 100 - 150€/m²
- > 150€/m²

Gewässer

- HWGK-Gewässer
- Sonstige Gewässer

Kartenbezeichnung:

Starkregenrisiko

Mittleres Niederschlagsereignis (ca. 120mm)

Legende:

Gewässer

- HWGK-Gewässer
- Sonstige Gewässer

Gebäude mit potentiellem Schadenpotential

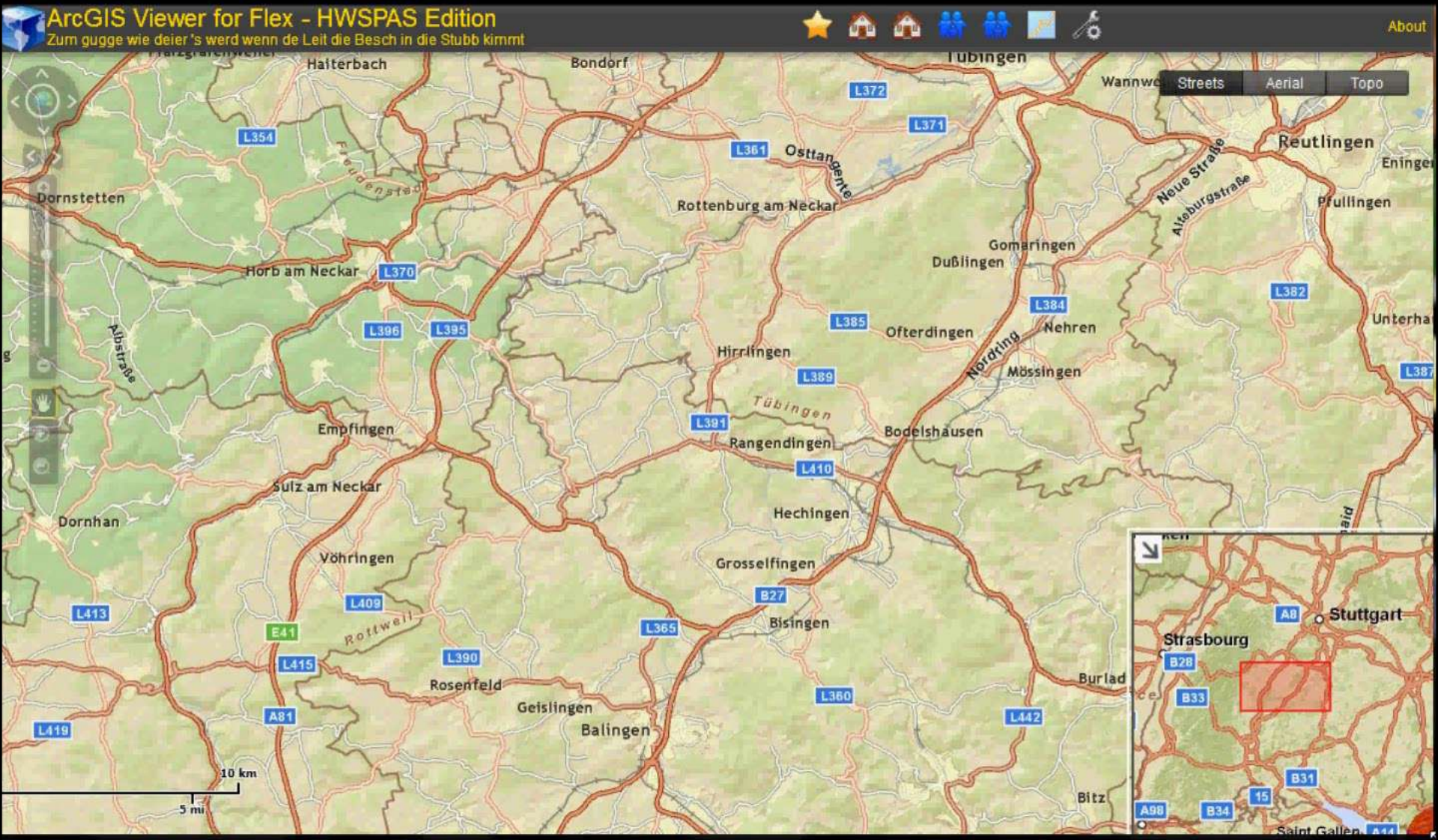
- undifferenziert

Betroffene Risikoobjekte

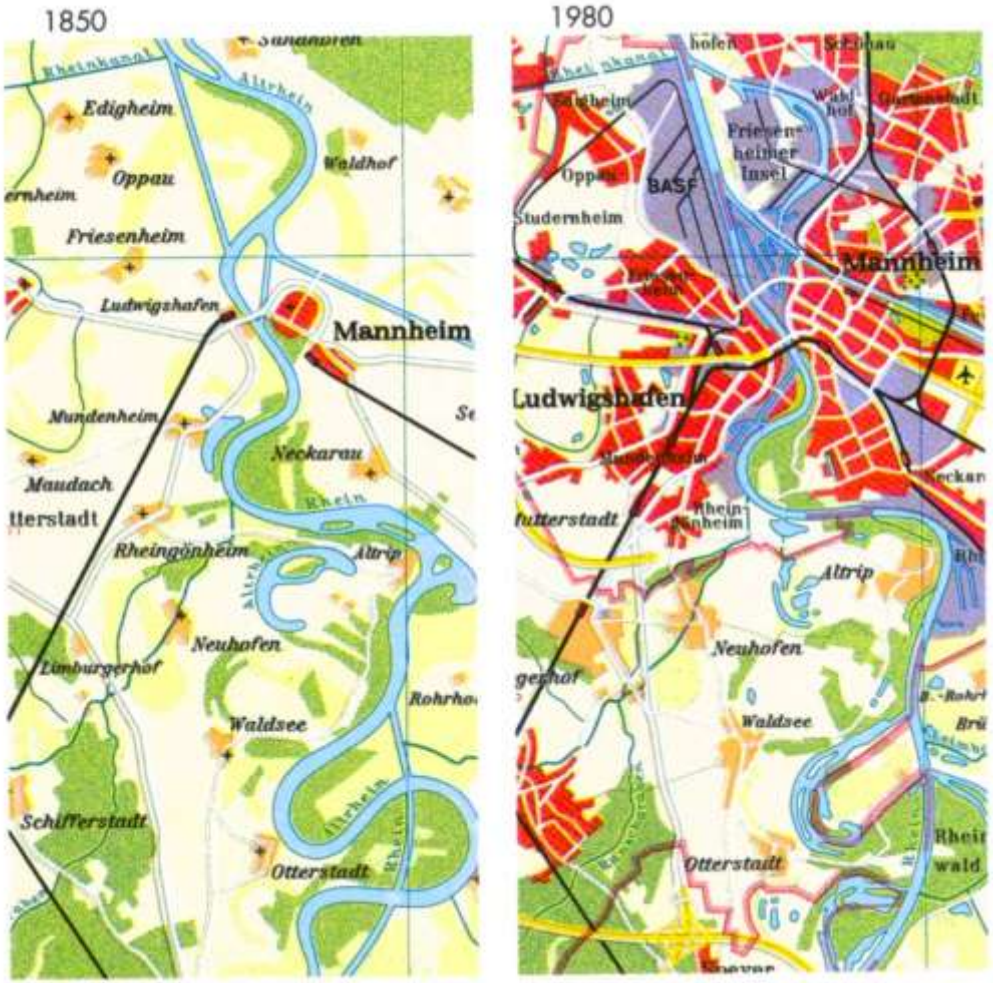
- Altersheim
- Badegebäude; Hallenbad
- Bibliotheksgebäude
- Campingplatzgebäude
- Energieversorgungsgebäude
- Feuerwehrgebäude
- Forschungsinstitut
- Gemeindehaus
- Gerichtsgebäude
- Heim
- Hochschulgebäude
- Hotel; Jugendherberge
- Justizvollzugsanstaltsgebäude
- Kapelle
- Kindergarten
- Kirche
- Kläranlagengebäude
- Krankenhausgebäude
- Messegebäude
- Museumsgebäude
- Müllverbrennungsgebäude
- Parkhaus
- Polizeigebäude
- Post
- Rathaus
- Schloß
- Schulgebäude
- Sportgebäude; Sporthalle
- Tankstellengebäude
- Tiefgarage
- Umformer
- Veranstaltungsgebäude; Vergnügungsstätte
- Verwaltungsgebäude
- Zoogebäude

Video animations

GI-Systems


ArcGIS Viewer for Flex - HWSPAS Edition
Zum gugge wie deier 's werd wenn de Leit die Besch in die Stubb kimmt
About
Streets
Aerial
Topo
Haiterbach
Bondorf
Tübingen
Wannwe
Reutlingen
Eninge
Dornstetten
Rottenburg am Neckar
Osttangente
Neue Straße
Alteburgstraße
Pfullingen
Gomaringen
Dußlingen
Horb am Neckar
Albstraße
Nehren
Unterha
Ofterdingen
Hirrlingen
Nordring
Mössingen
Tübingen
Empfingen
Rangendingen
Bodelshausen
Sulz am Neckar
Hechingen
Dornhan
Vöhringen
Grosselfingen
Bisingen
Rottweil
Rosenfeld
Geislingen
Balingen
Burlad
Bitz
Stuttgart
Strasbourg
Saint Gallen
10 km
5 mi
L354
L372
L371
L361
L370
L396
L395
L385
L384
L382
L389
L391
L410
L413
L409
E41
L415
L390
L365
B27
L360
L442
A81
L419
A8
B28
B33
B31
15
A98
B34
A11

Changes?



Thank You!

Stryszawka, Poland
September 2011