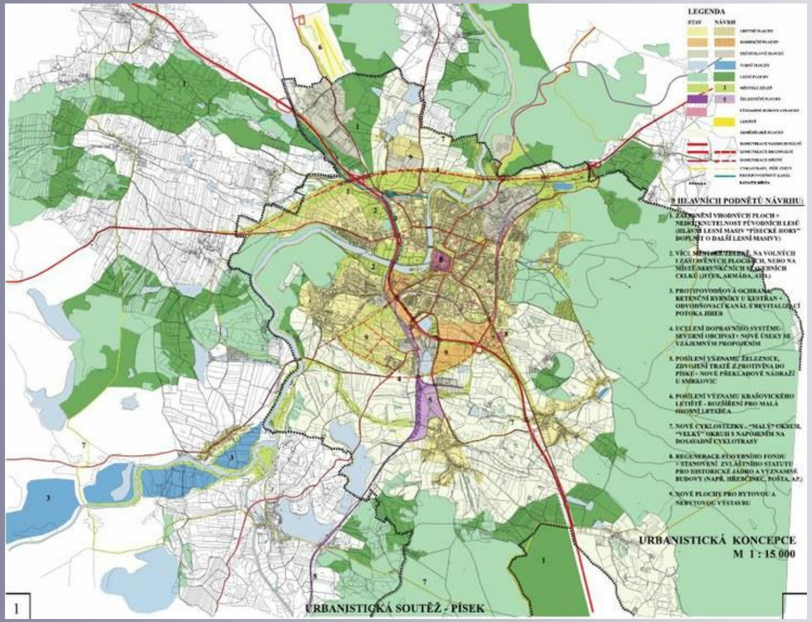
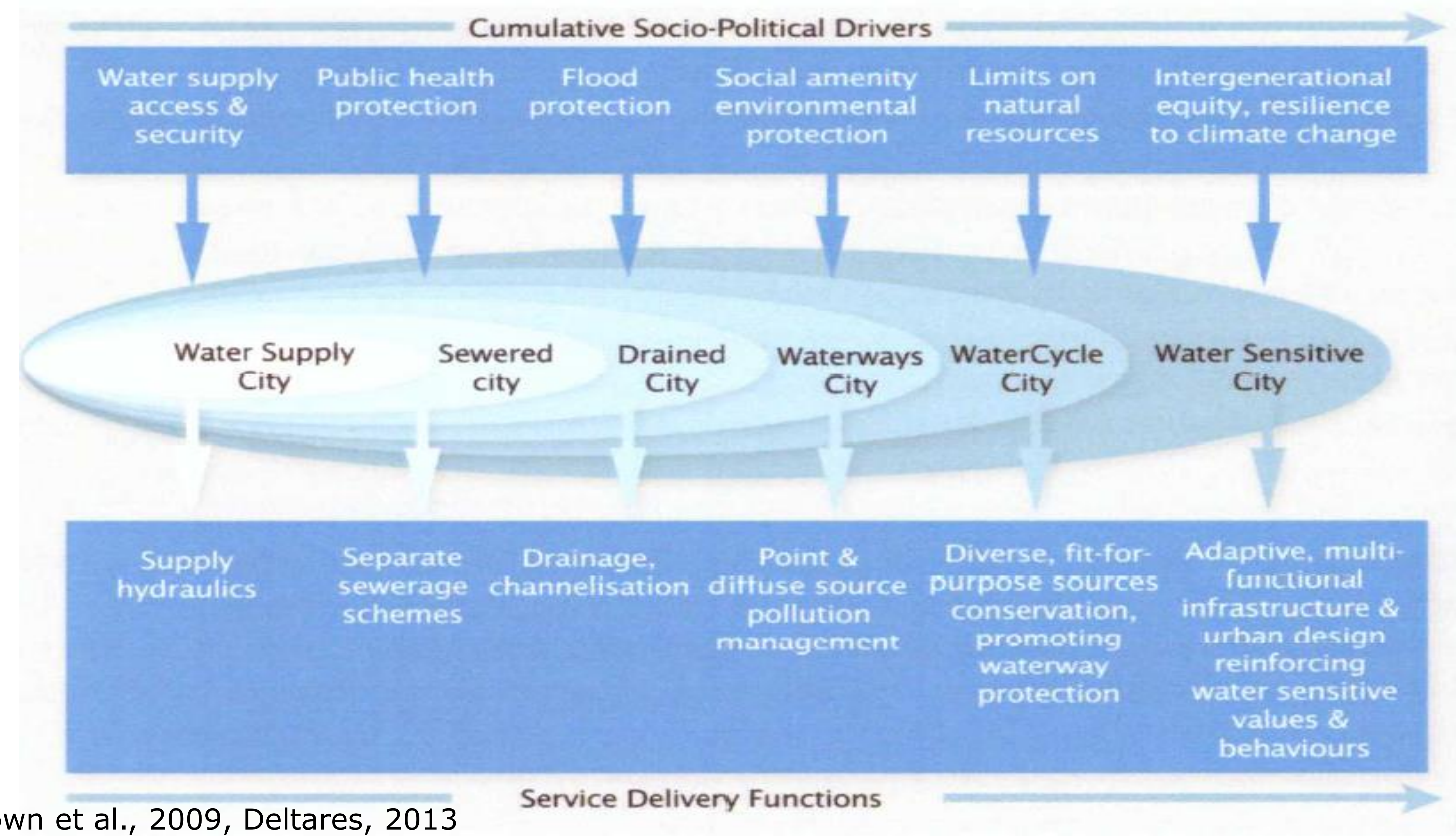
Applied Hydroinformatics I.



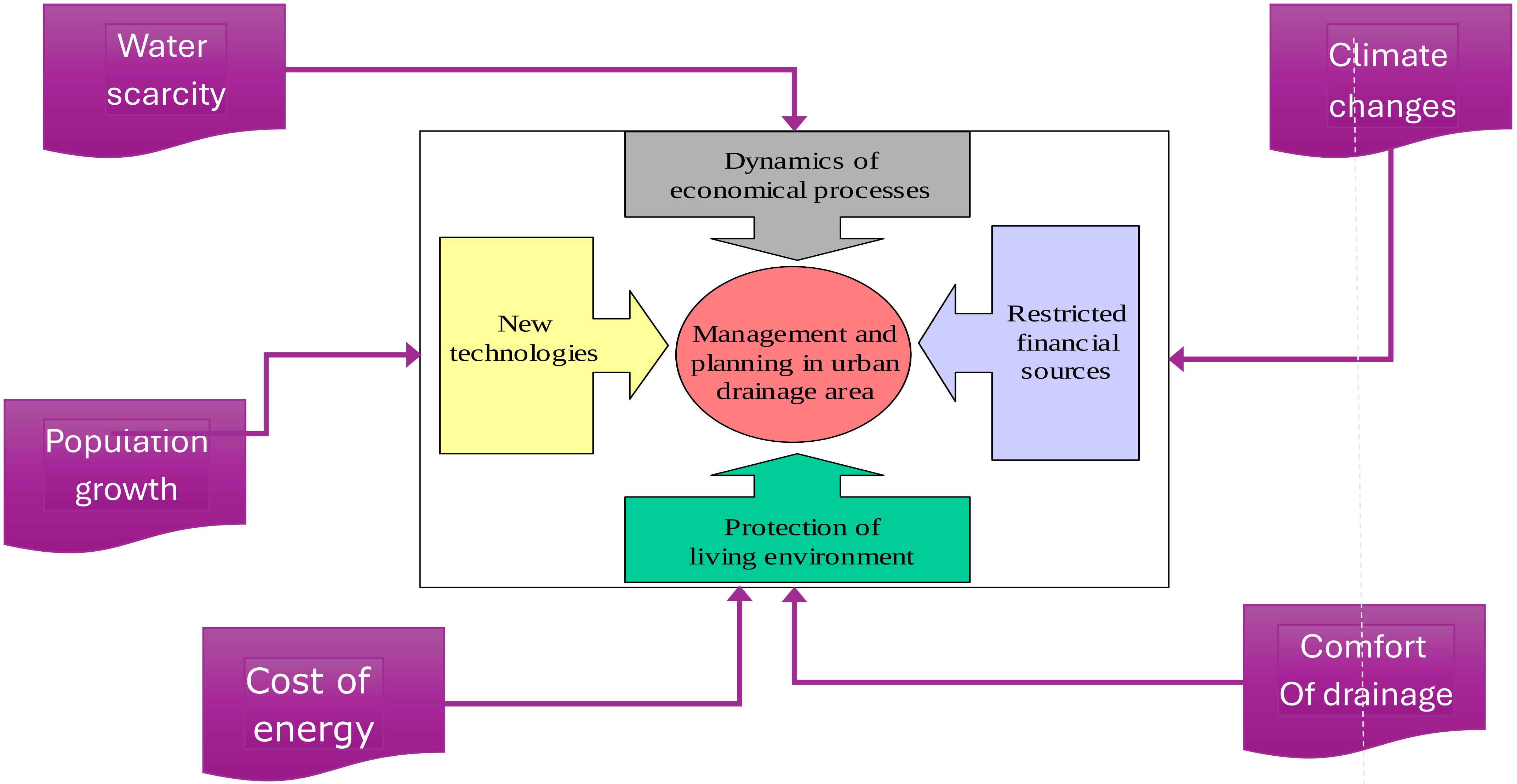
Urban Infrastructure
as
Complex system

Historical development of urban infrastructure



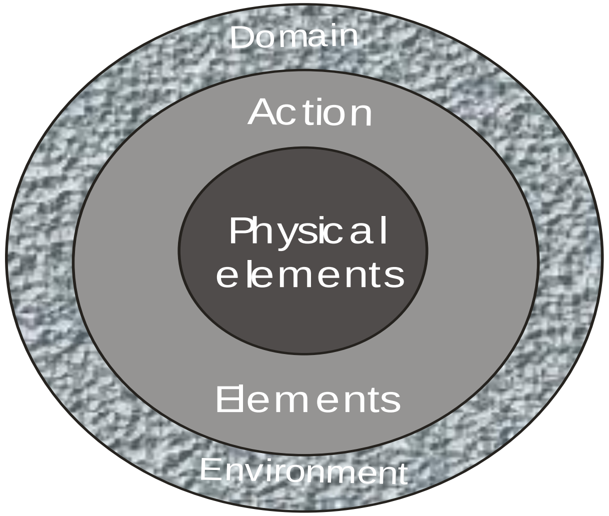
Brown et al., 2009, Deltares, 2013

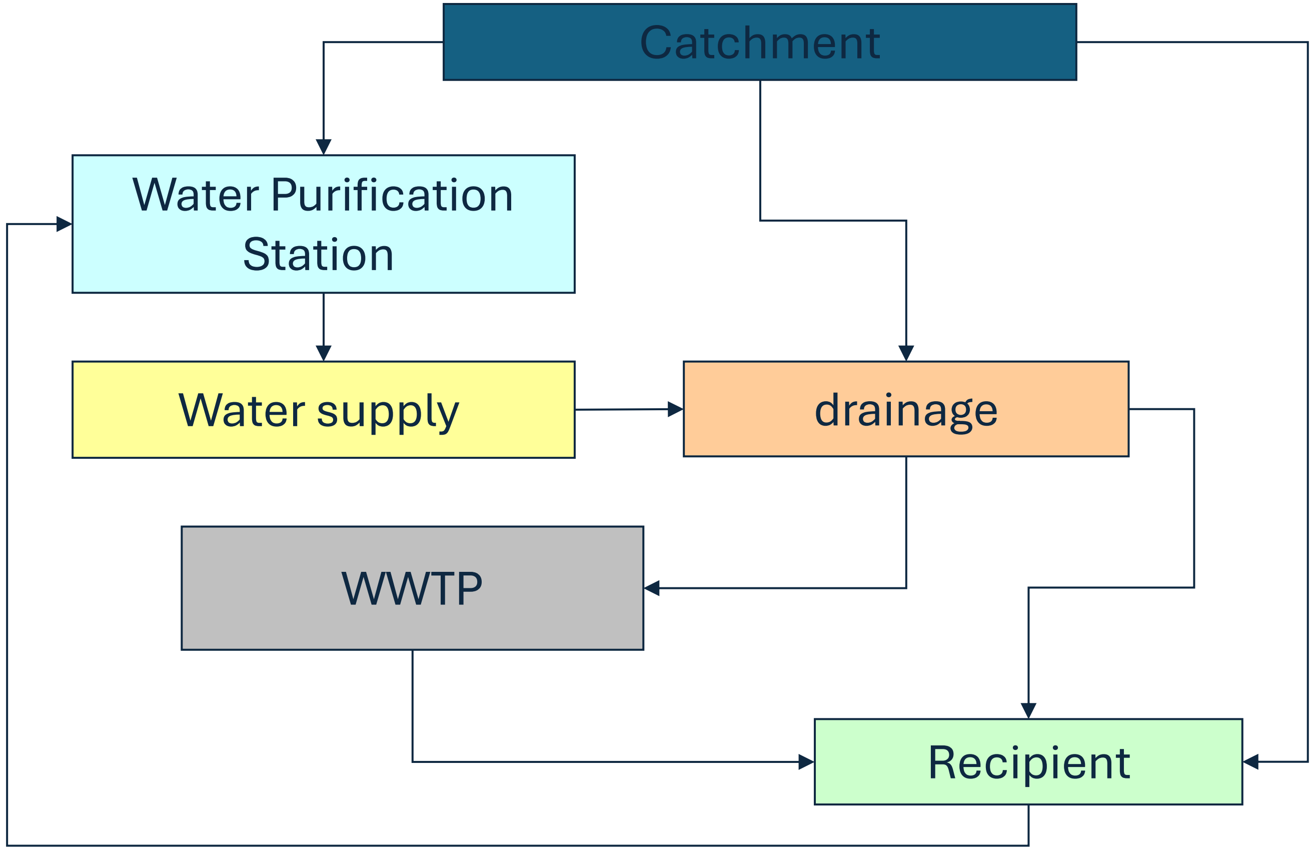
Changing Environment in Urban Infrastructure

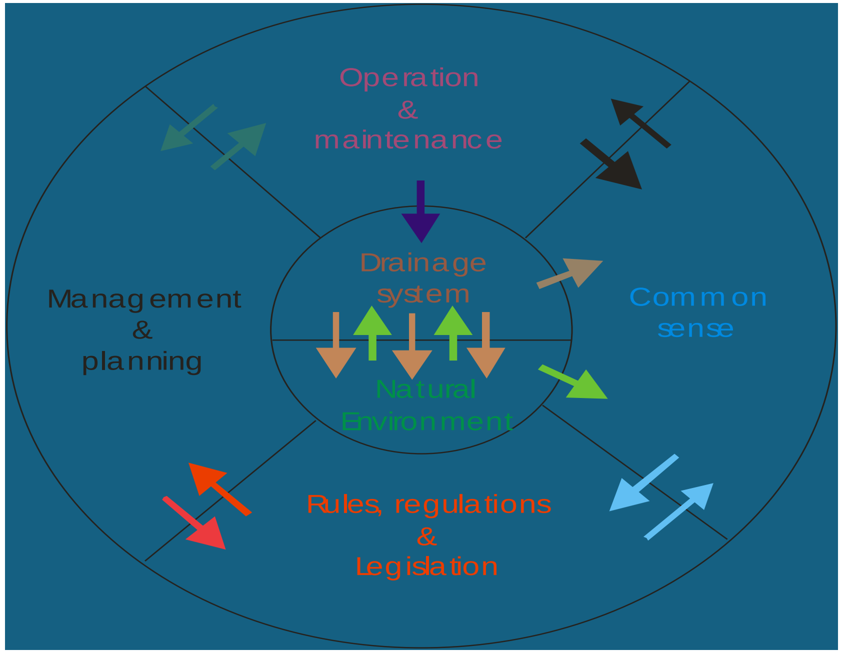


Complex System of Urban Infrastructure

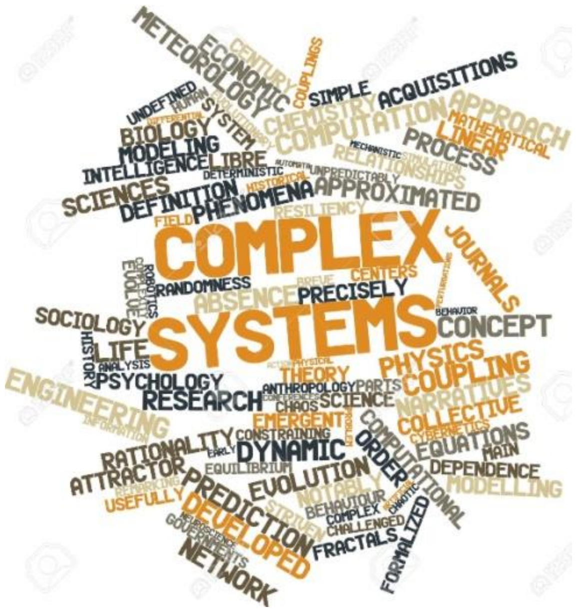
"A complex system can be defined as a set of inter-related components forming a body with the defined function. This function cannot be realised by any of the individual components on its own, but only through the contribution of all components," Bertalanffy,1965).







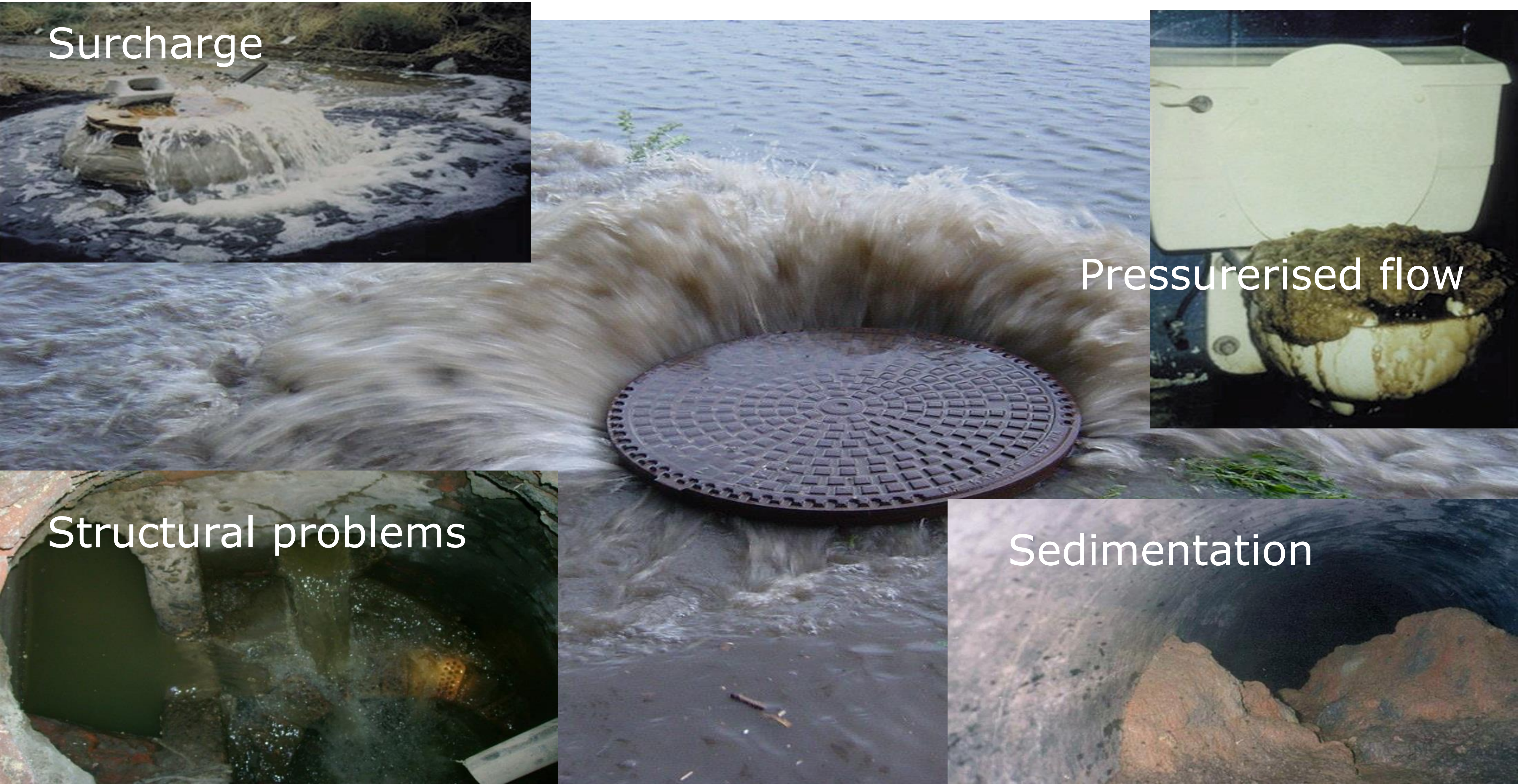
Limits of Complex systems



Large cities inhabit more than 50% of world population
And consume 80% of energy and produce 75% of CO2 emisions.

1. **Growing complexity of systems** tends to growing complexity in management and planning
2. **Domino effect of failures** in operation
3. **Price of maintenance** growing
4. **Robustness** of complex systems problematic
5. Question of centralized and **decentralized urban water systems**

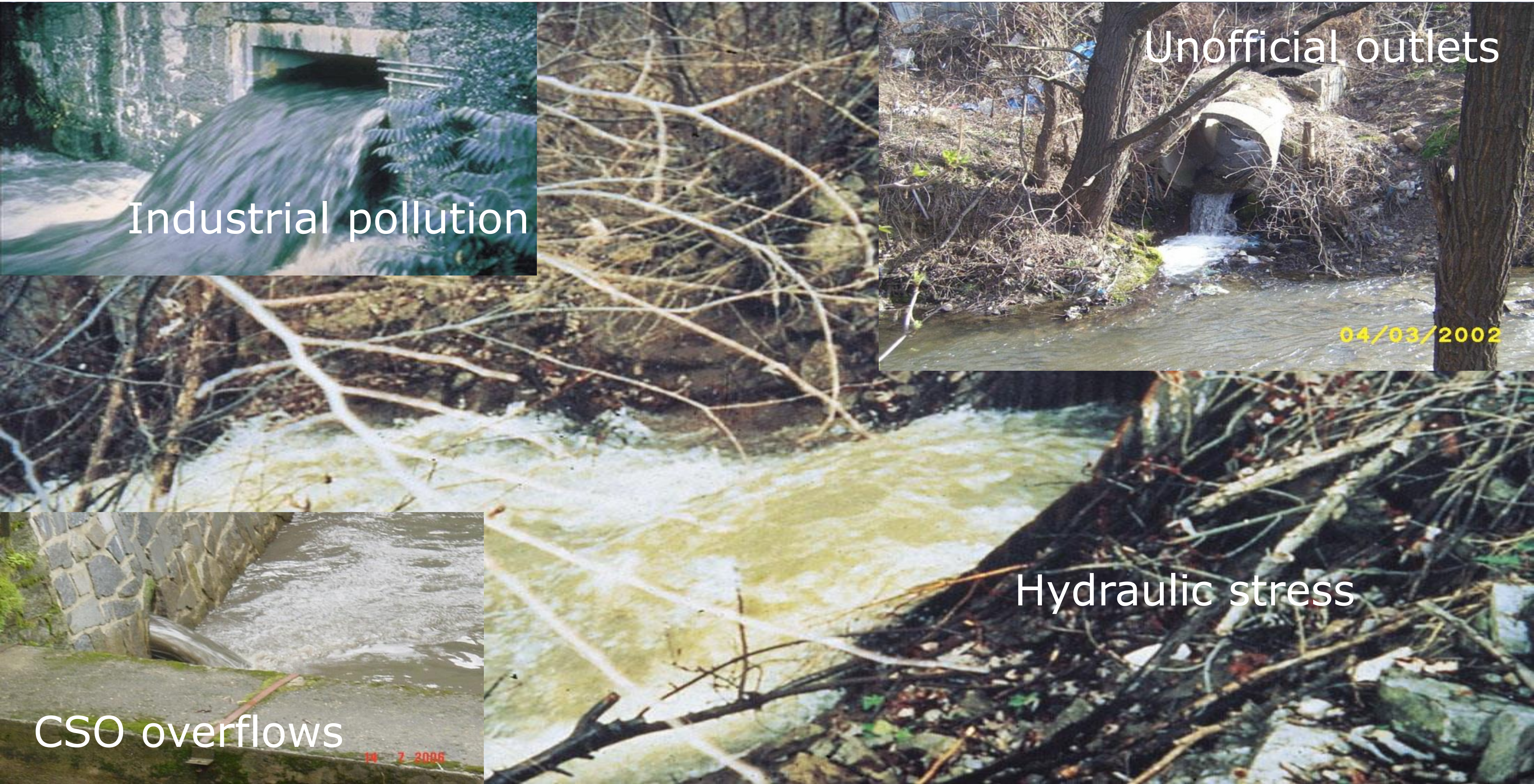
Sewerage system failures



Water supply system failures

WWTP failures

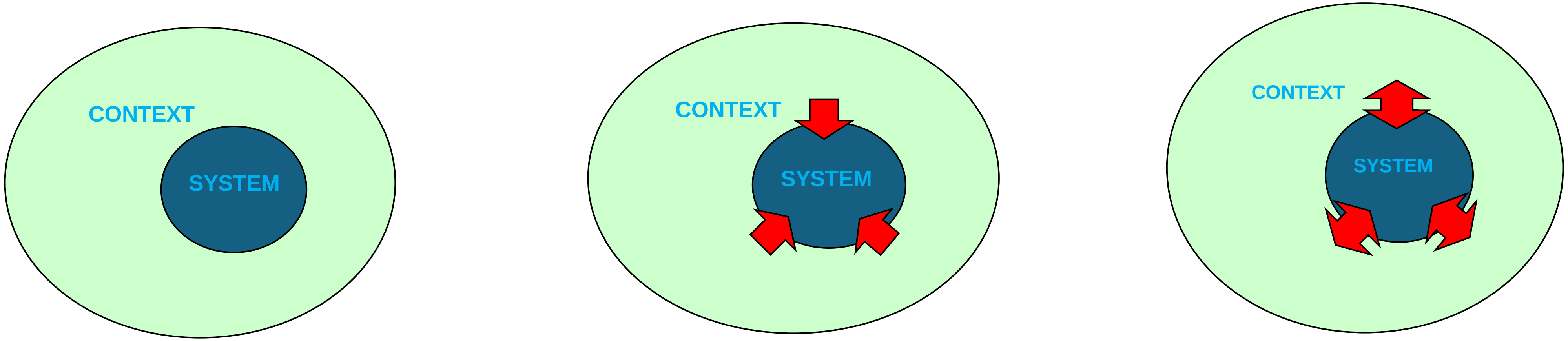
Water quality failures



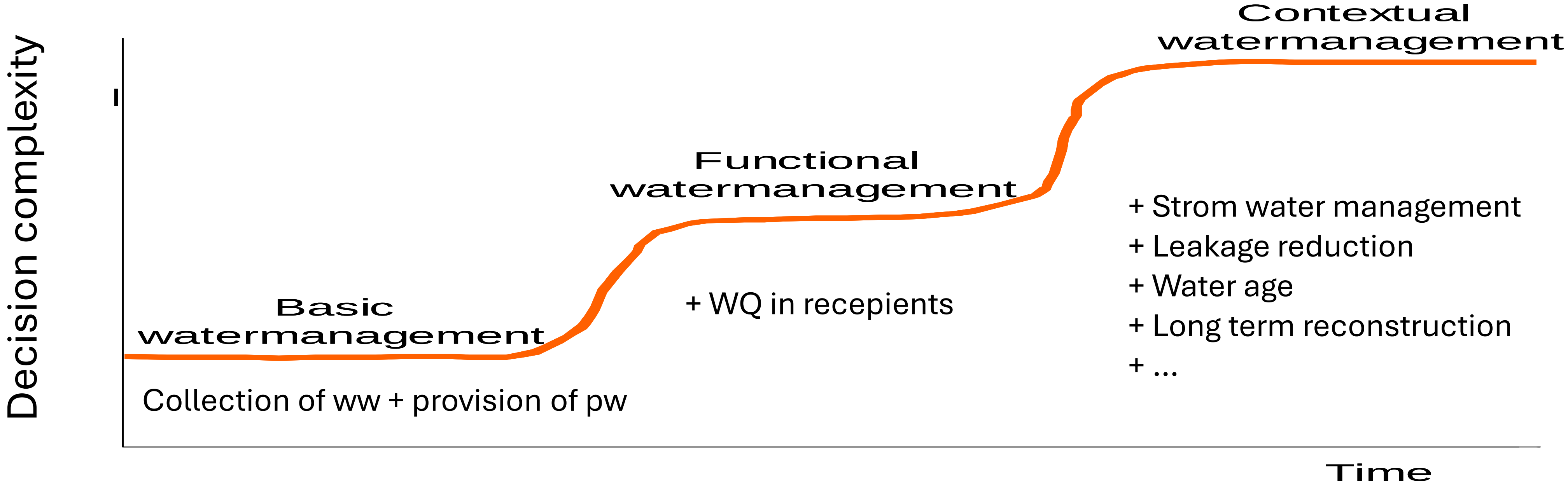
FLOOD FAILURES

Flood Prague 11.8. 2002

Changes in Urban Infrastructure Management



Basic management Functional management Contextual management



Urban infrastructure decisions complexity

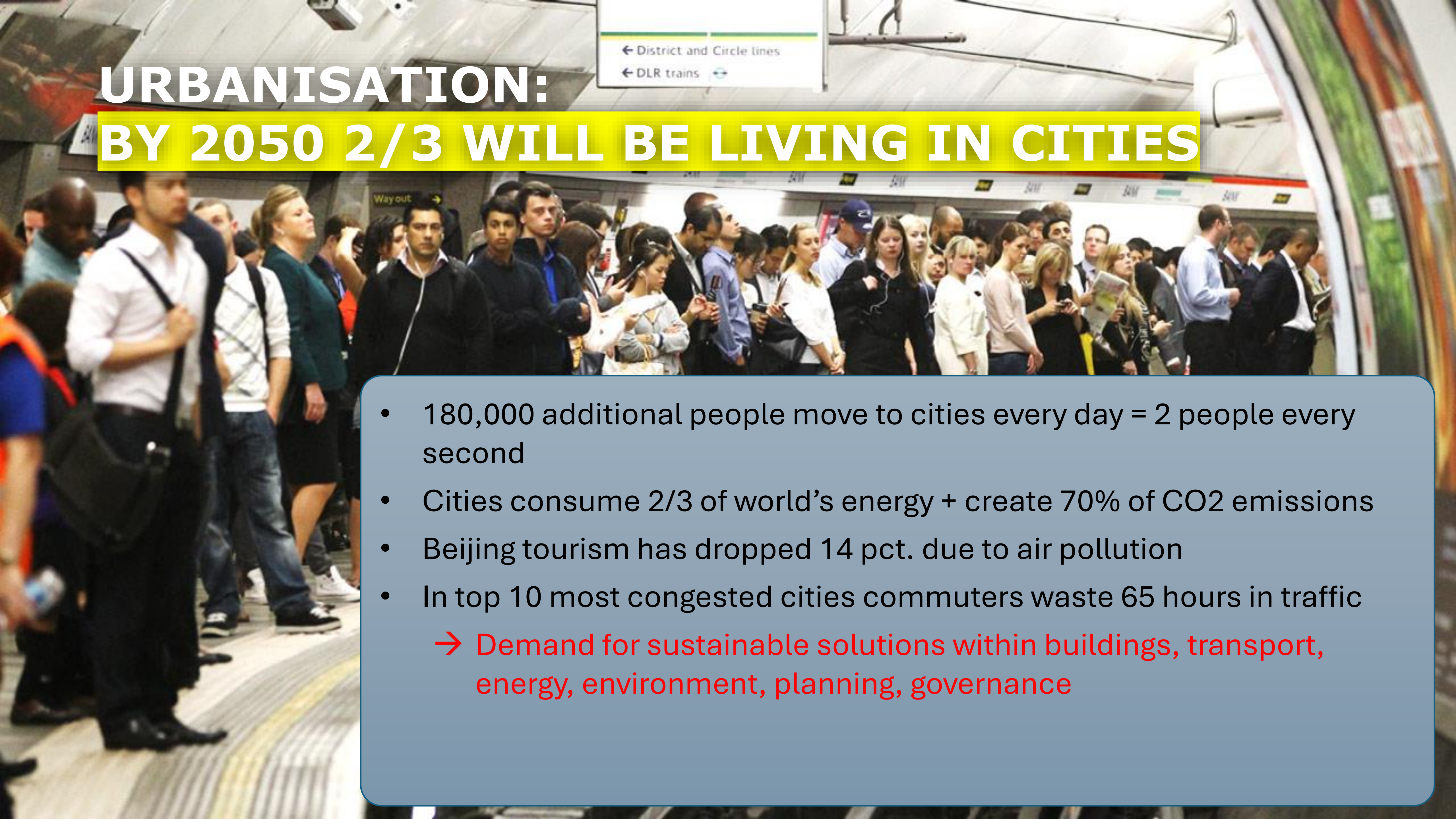
- Growing **quantity of information** / data
- Growing **spectrum of information** / data
- Growth in **Information technolog**ies (RDBMS, GIS, KB, DSS ...)
- Growing complexity of services
- Pressure form **Competitors, Clients**
- **Financial pressure**
- Pressure on **immediate decision**

Risk of wrong decisions

Changes in Living Environment
(context)

The world global megatrends

Demographic changes	Urbanisation	Climate change & Environmental problems	Resource scarcity	Globalisation	Digitisation
Overpopulation, ageing population, state of health, increasing education, growing middle class	New infrastructure, increase in redevelopment, waste, water, pollution	Degradation of ecosystem, global warming conditions	Increasing global demand, economic austerity	Global division of labour, goods, services, communication, mobility, transportation	Processes and society in general are increasingly digitalised



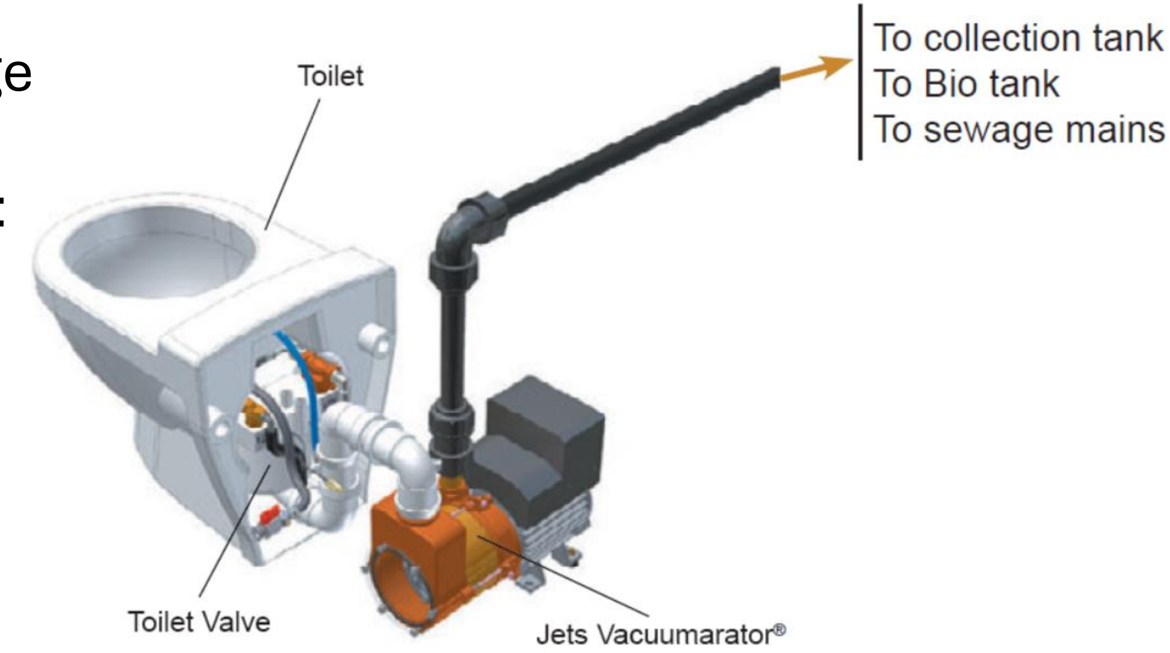
URBANISATION:
BY 2050 2/3 WILL BE LIVING IN CITIES

- 180,000 additional people move to cities every day = 2 people every second
- Cities consume 2/3 of world's energy + create 70% of CO_2 emissions
- Beijing tourism has dropped 14 pct. due to air pollution
- In top 10 most congested cities commuters waste 65 hours in traffic

→ Demand for sustainable solutions within buildings, transport, energy, environment, planning, governance

Scarce water sources

1. **Cost of water is growing**
2. **Storm water** is gradually getting **important source**
3. Water r**ecycling** and water savings in households
4. **Disconnection of storm water** from sewerage
5. New requirements on **wastewater treatment**
6. **Wastewater** as **source**, not vaste
7. “**Circular economy**”

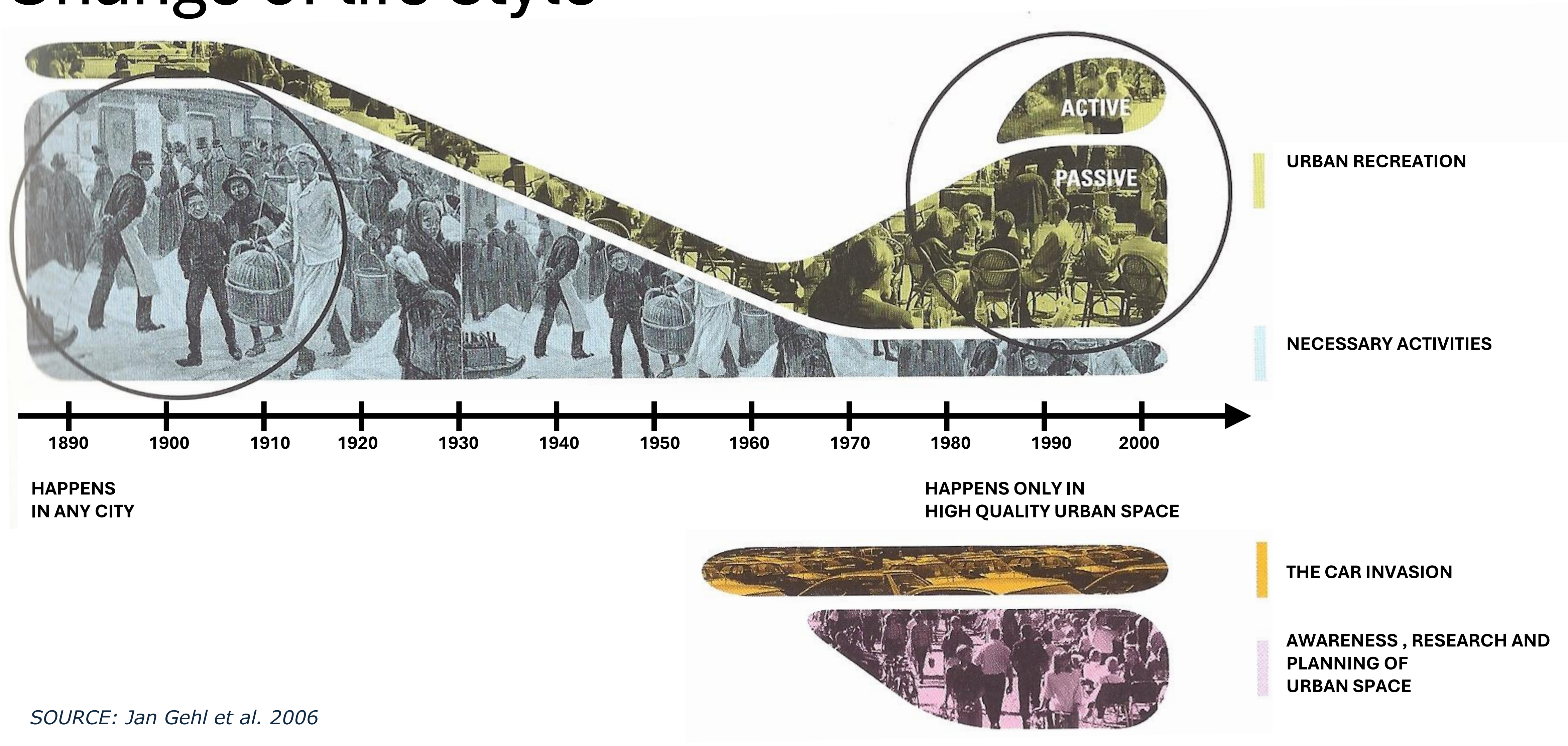


Zdroj: JETSGROUP (2005)

Technology impact

1. **Smart sensors** and monitoring systems
2. **Big data**, data analyses
3. **Real time simulation**, forecasts
4. **Smart cities**
5. Water as comodity in **Internet of things**
6. **AI…**

Change of life style



SOURCE: Jan Gehl et al. 2006

Copenhagen y.1900


COPENHAGEN 2014

Bucharest - river Dumbovitza - today

Bucharest – river dumbovitza – future

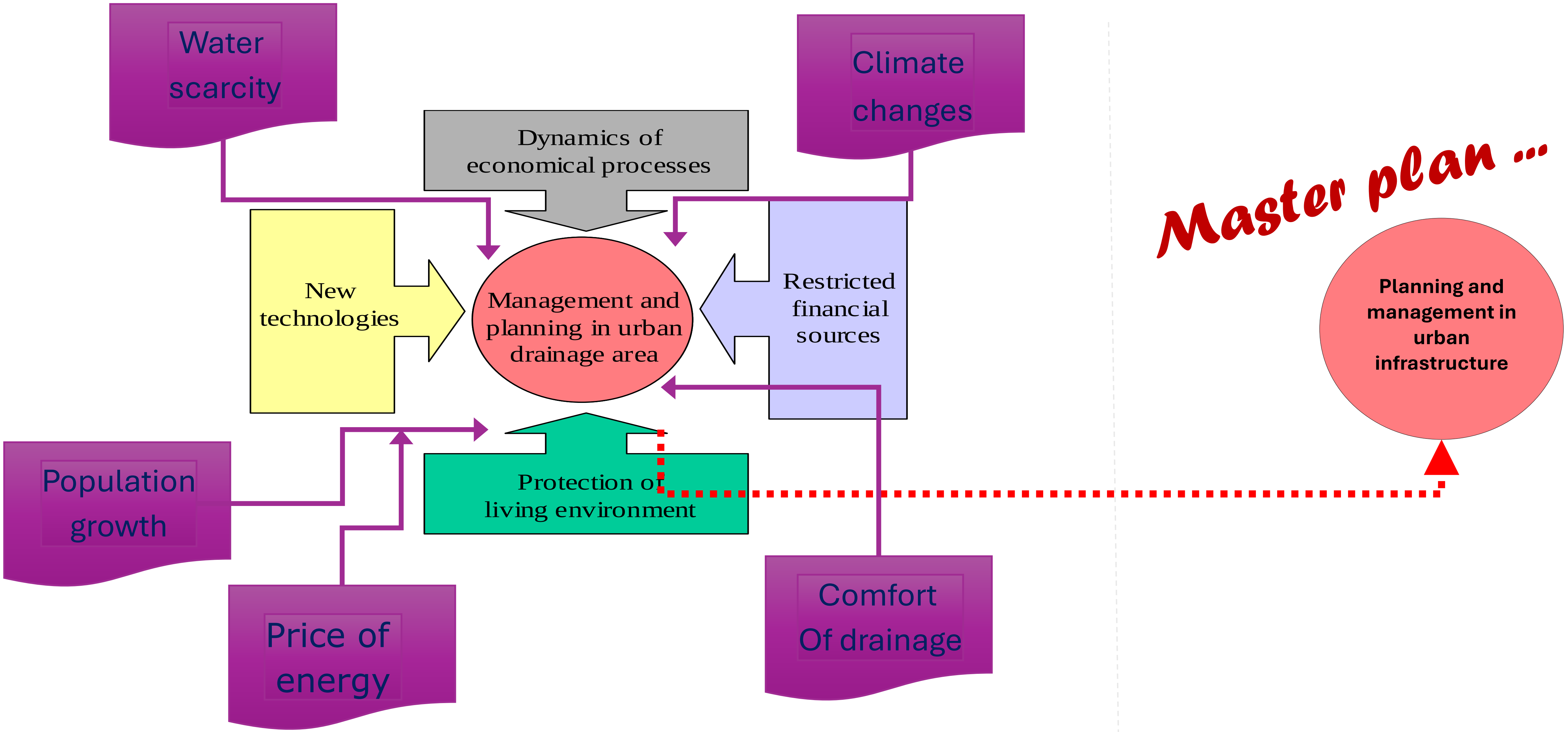
Urban Water Master planning

Urban Water Master Plan

goals, objectives, purpose

1. **Conceptual document** focusing on future sustainable **long term development of city water infrastructure**
2. Defines future development **framework, boundaries, limits** for defined **time horizons**
3. MP is the **source** of information **for City development plan**
4. MP is founded in local and EU **legislation** (UWWD,WFD, DWD, etc.)

Changing Environment in Urban Infrastructure



OLD Master plans (30-80'es)

20th century – **need for systematic planning process** in urban water infrastructure in relation with industrial revolution consequences

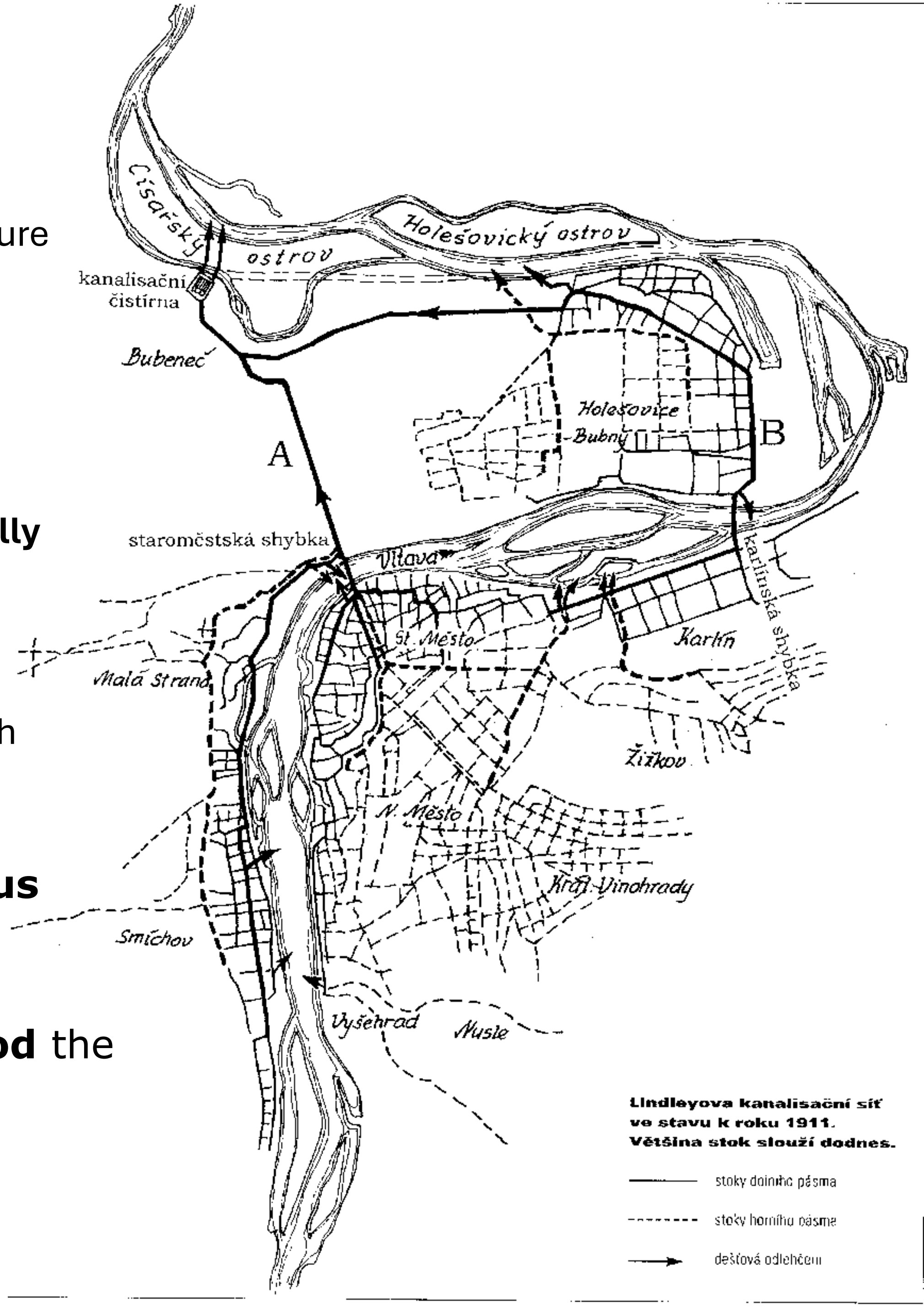
Y-1925 – Ing.Máslo prepared 1st urban water MP for Prague in relation with **industrial development of the city**

The only single elementary requirement for this conception – **fast and hygienically secure transport of sewerage waters to the WWTP**/ recipient.

Methodology of the MP was based on **rational design method** incorporating both sewage and runoff water into one combined system.

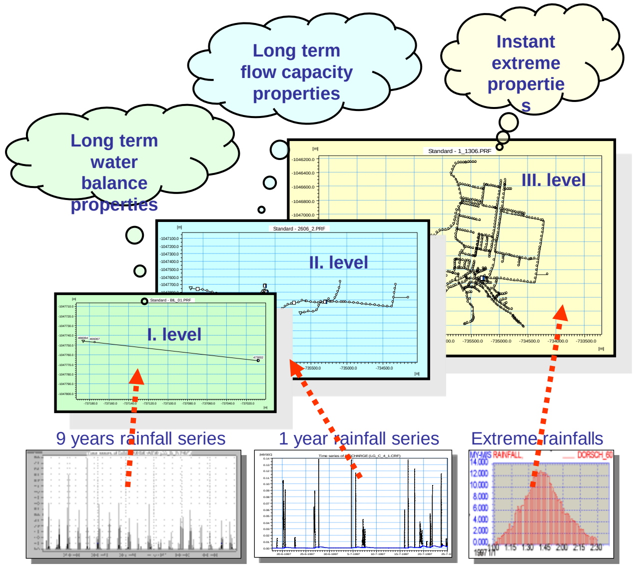
Master plans were elaborated in **paper form without broader focus** on real system performance.

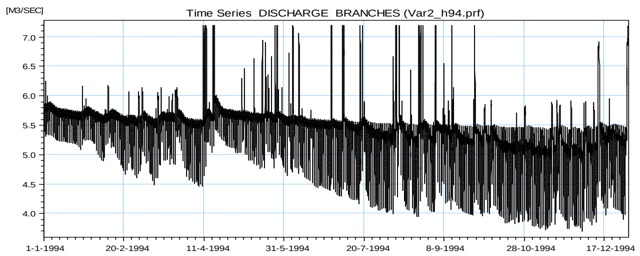
Thanks to **capacity reserves implemented in the rational method** the sewerage systems are operating well till present time.

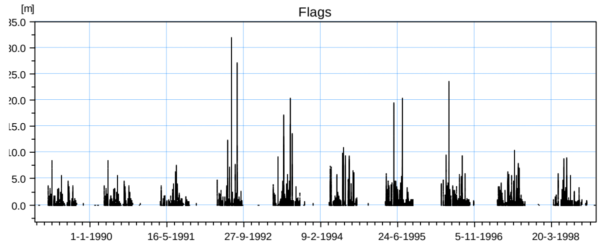


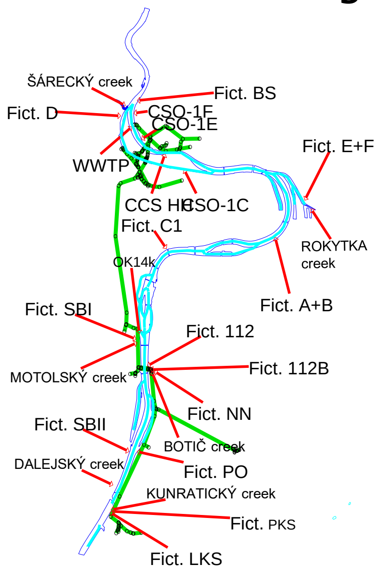
Complex master plans (1990-today)

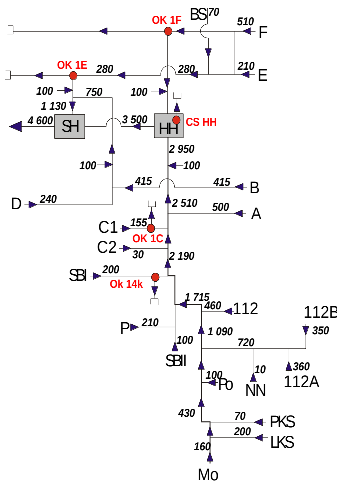
1. **Legislative requests EU/local (**91/271/EEC) protection of recipients
2. **Integrated approach** (network, catchment,recipient, WWTP)
3. Use of **information technology** = simulation model, GIS, DB,...
4. Large **data needs**
5. **Complex view on performance of** water infrastructure
   - CSO and recipient
   - Flood protection
   - Storm water management
   - Planning of network reconstruction

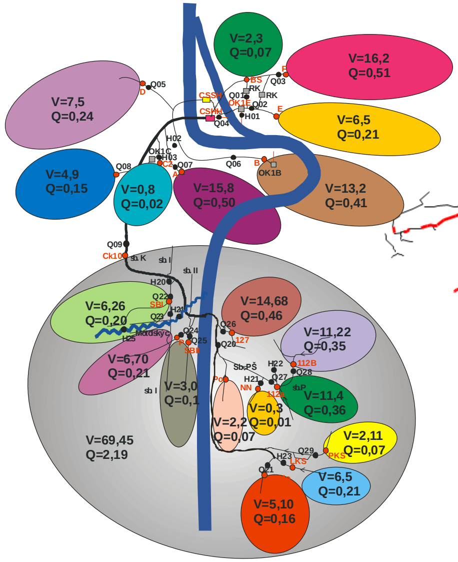


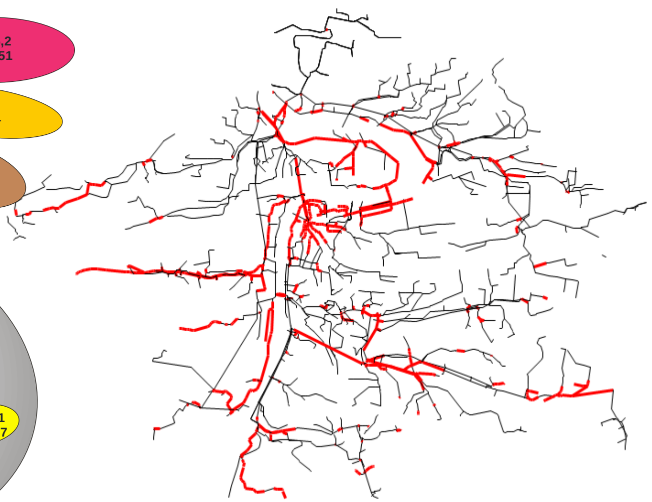


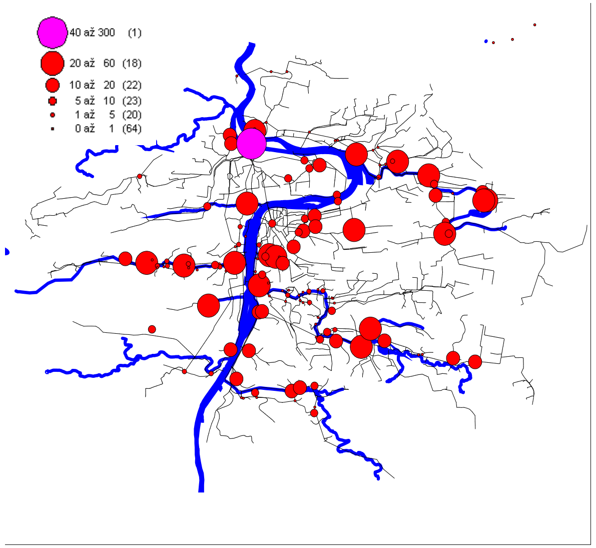












Master plan brings changes …

- Direct connection **to city development plan**
- Connection to **flood protection plan**
- **Data sharing with** other systems
- **Monitoring** in the network and catchments
- **New methodologies**
- **Model calibration**/verification
- **Water quality issues**
- **Risik analysis**

Master Plan approach

1. Use of **Integral approach** (water sources, catchment, network, treatment plant, receiving water)
2. Use of **simulation modelling** technology
3. Use of **digital data** (GIS, DB)
4. Principle of **continuity**

Methodological Corner Stones

1. Demographic (**pesimistic, realistic optimistic) forecasts**
2. **Key performance indicators** and target values
3. **Option analysis** and use of scenarios
4. **Cost - benefit** analysis
5. Short, medium, long term **investment plan**
6. Environmental **Impact assessment**
7. **Risk assessment**

Master Plan Goals and Objectives

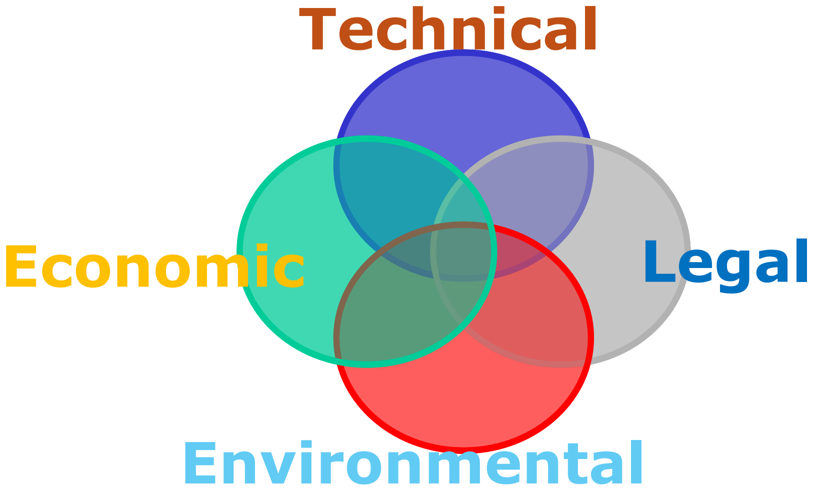
1. **Urban development objectives**
   a. New development areas
   b. Trends in population growth
   c. Comfort of drainage,

2. **Urban water supply and drainage targets**
   a. Storm water control in catchments
   b. Transport of water and pollution in sewers
   c. Flood protection
   d. Protection of receiving waters (river, see)

3. **EU and local goals / directives**
   a. To achieve the accordance to EU regulations (98/83/ES, 75/440/ES, 91/271/EHS, 2000/60/ES,…)

4. **Key performance indicators and their limits**
   a. Surcharge ratio, % impermeable surface,
   b. CSO – spils number, volume, duration,...
   c. Hydraulic stress in the river, ...

5. **Simulation boundary conditions**
   a. Selected extreme rainfalls, long term simulation, ...



Master Plan Structure and content

1. Definition of **study area** (socio-economic and natural conditions)
2. Project information and data sources
3. Urban water supply and drainage system description
4. **System gaps**, deficiencies in existing infrastructure
5. **Project goals**, objectives (political, technical, environmental)
6. Projected **forecasts** (demographic, water consumption)
7. **Surveys**
8. **Model build** and calibration
9. Current/future state system **option analysis**
10. Proposal for structural and non/structural **measures**
11. Economic and **financial evaluation**, **cost benefit analysis**
12. Short, medium and **long term investment plan**

Technical Key Performance Indicators

- **Surface** - FRC, SRC, FF volumes, total diverted volume
- **Capacity** - return period of capacity Q, Q max, cumulative frequency distribution curve
- **Retention** - retention time, transformation ratio Qmax_in - Qmax_out, retention volume
- **Transport** - minimal velocity, dry weather discharge
- **Flood** - Qmax, Hmax, total Flooded volume, time T to start of flooding, time T to Qmax
- **Emission** - Overflow No., total time of overflows, total overflow volume, Q max
- **Imission** - Q max/Qriver, BOD, Ammonia, dissolved solids (after mixing in river)

Financial Key Performance Indicators

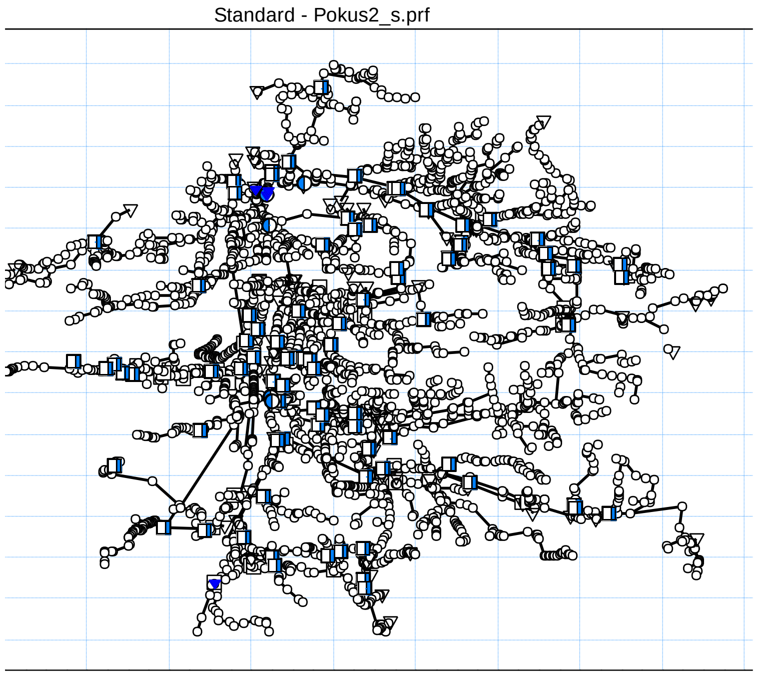
1. **Land property** cost
2. **Design and construction** cost
3. **Purchase** cost
4. **Operation and maintenance** cost
5. **Associated** costs (to mitigate environmental impact)

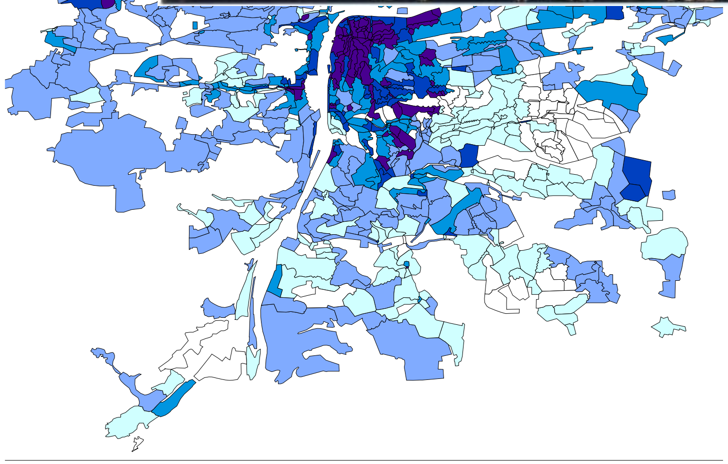
Net present value

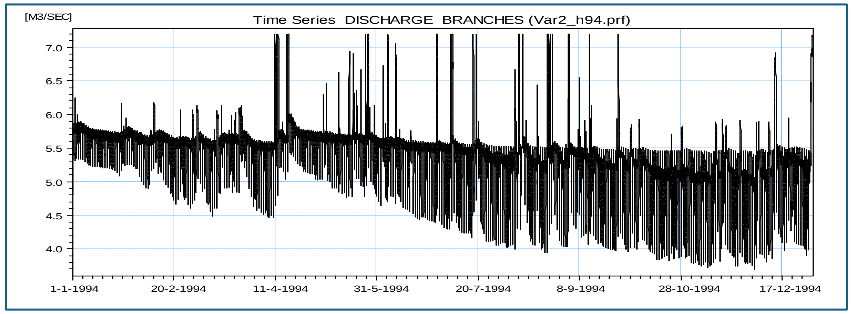
Prague Urban drainage master plan

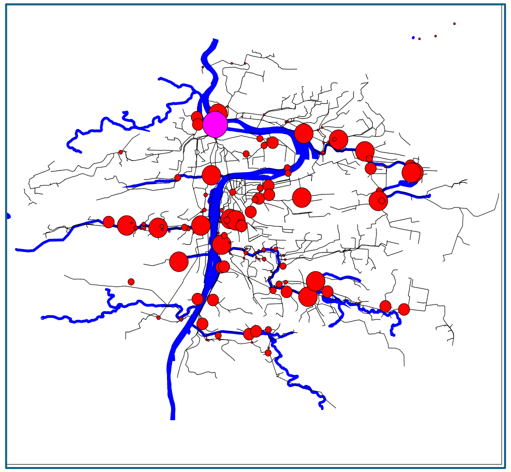
Year: 1999-2001

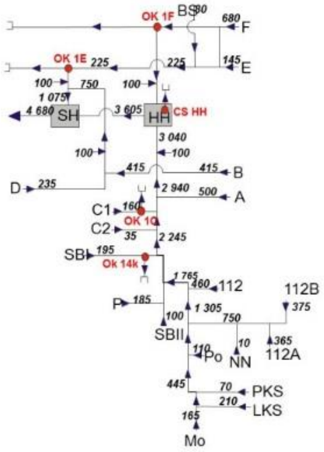
- Sewer + River
- Monitoring
- Digi data
- New results

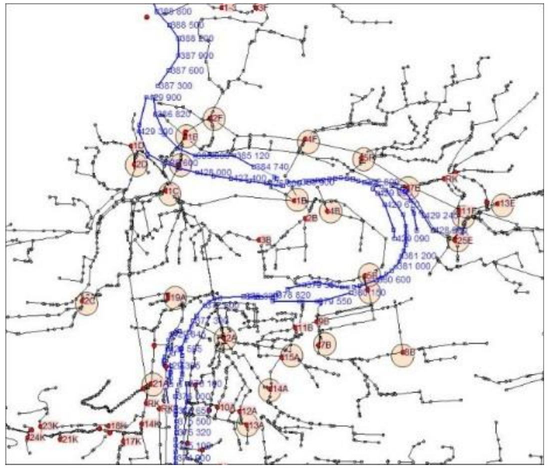




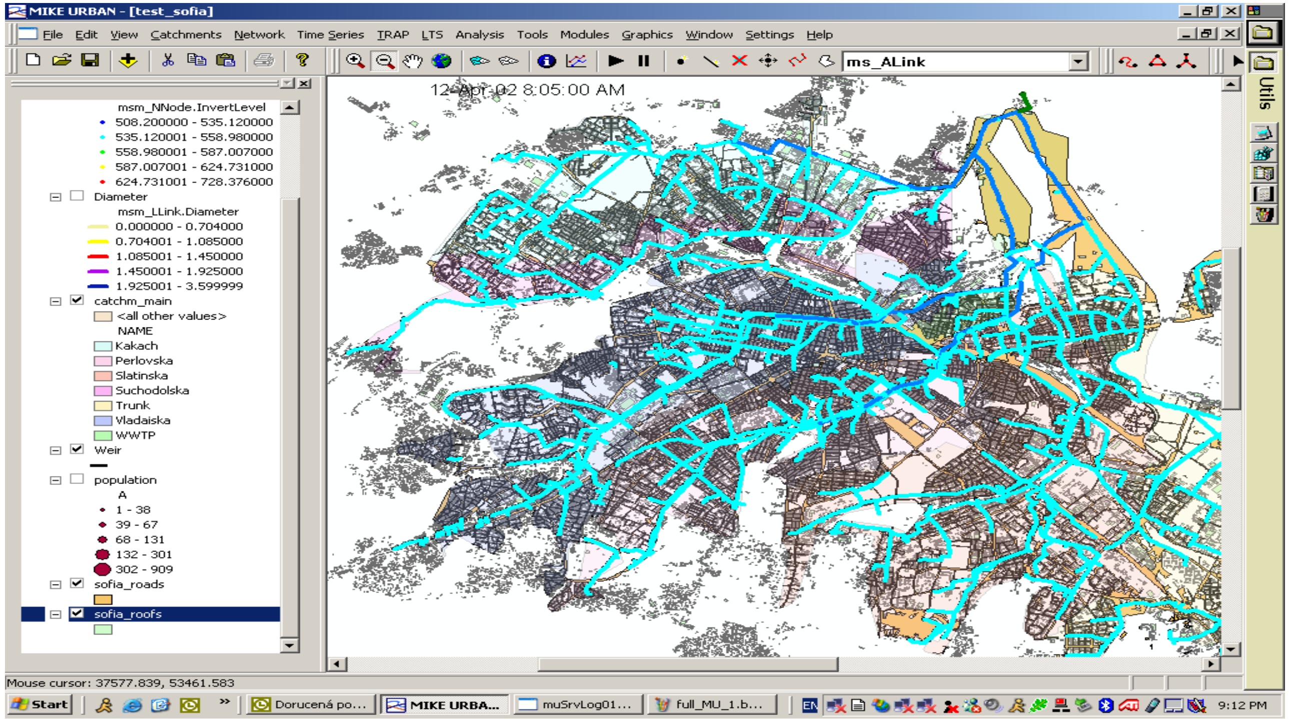


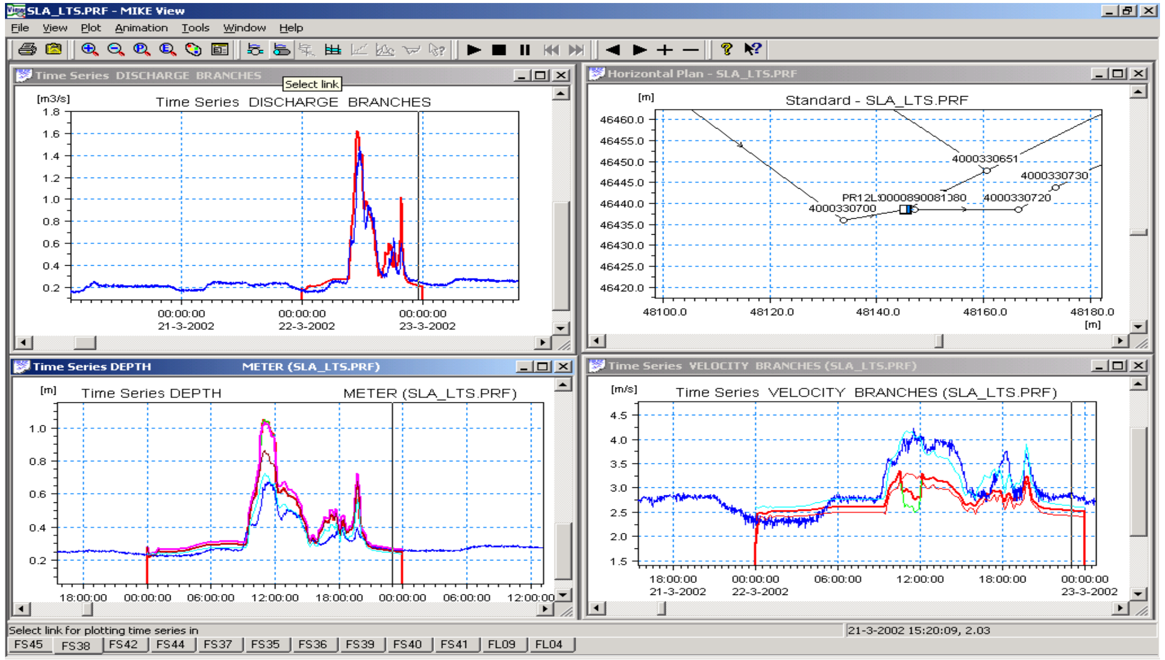






Sofia Drainage Area Plan (DAP) **2002 - 2003**

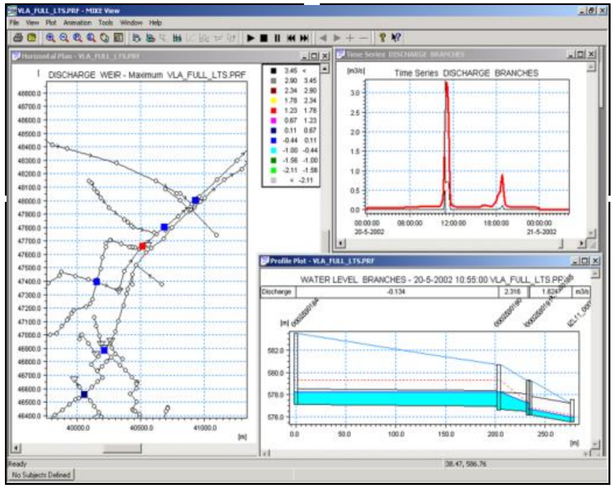


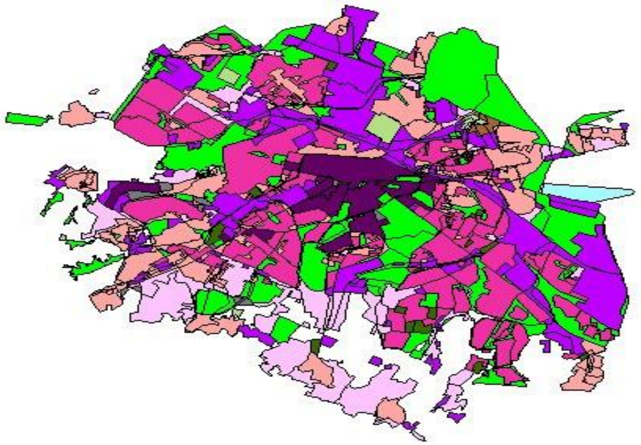


KEY

- xxx (black): No observed data recorded
- xxx (yellow): See individual event comments for reasons for non-compliance
- xxx (light blue): Recorded velocity errors (resulting in criteria non-compliance)
- xxx (blue): Recorded depth errors (resulting in criteria non-compliance)
- NS: Not in surcharge conditions
- xxx (purple): Recorded depth & velocity errors (resulting in criteria non-compliance)
- xxx (light green): Average within criteria - considered verified
- xxx (green): Average not within criteria due to recorded errors (or no data) - model acceptable
- xxx (red): Average not within criteria - see individual comments for potential model limitations

Ref	Comparative analysis		Event A	Within Criteria?	Event B	Within Criteria?	Event C	Within Criteria?	Average	Within Criteria?
	Peak Flows	(%)	13.0	YES	-6.0	YES	-18.4	NO	-3.8	YES
FS61	Flow Volume	(%)	28.4	NO	15.1	YES	1.9	YES	15.1	YES
	Peak Depths	(mm)	85.0	YES	34.0	YES	20.0	YES	46.3	YES
	Peak Flows	(%)	11.3	YES	13.0	YES	-38.1	NO	-4.6	YES
FS62	Flow Volume	(%)	0.7	YES	-1.5	YES	-27.4	NO	-9.4	YES
	Peak Depths	(mm)	70.0	YES	43.0	YES	5.0	YES	39.3	YES





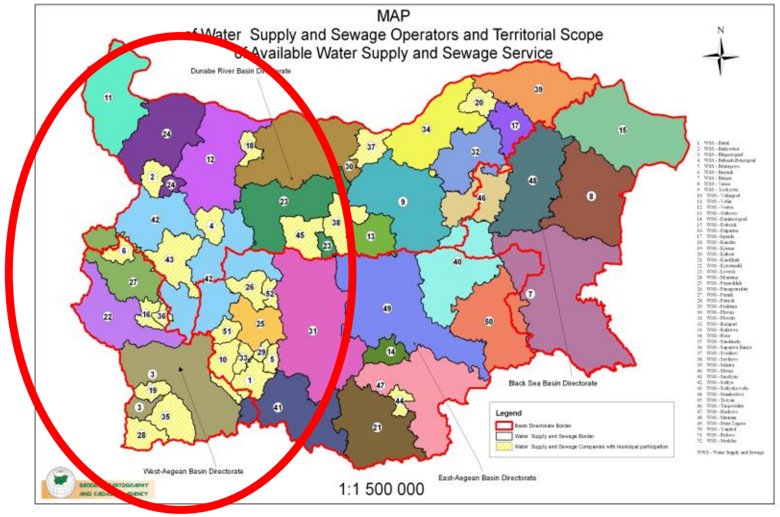
Technical assistance for projects preparation in water sector – group A - Burgas, Gabrovo, Kustendil, Ruse, Sliven and Vratsa –

2010-2011

PREPARATION OF REGIONAL WATER AND WASTEWATER MASTER PLANS FOR WESTERN REGION MIDP-MP-QCBS3

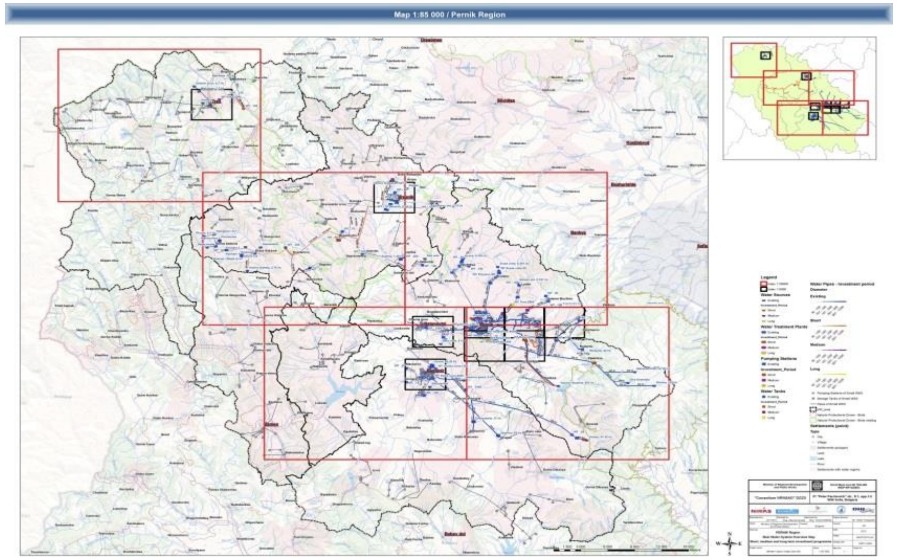
GOALS

1. Remediation of major deficiencies in water quantity and quality
2. Compliance with BG and EU legislation
3. Increase of system efficiency and sustainability
   a) NRW reduction
   b) Energy savings



OBJECTIVES

1. Current state of water supply and drainage, its needs bottlenecks
2. Projections of the population and industry growth in next 25 y.
3. Proposal for future water consumption limits
4. Option analysis for long term sustainable system development
5. Priority plan for reconstruction and new investments
6. Short (2020), medium (2028), long term (2038) investment plan



Sopron storm water master plan

Year: 2012-2014

- City flood defense
- SWM, water management
- Integration in City planning
- Risk analysis