Open Eyes – Economy Summit

Wroclaw - 24-25 September 2018

Water and Quality of Life in Cities

Uri Shamir

Professor Emeritus

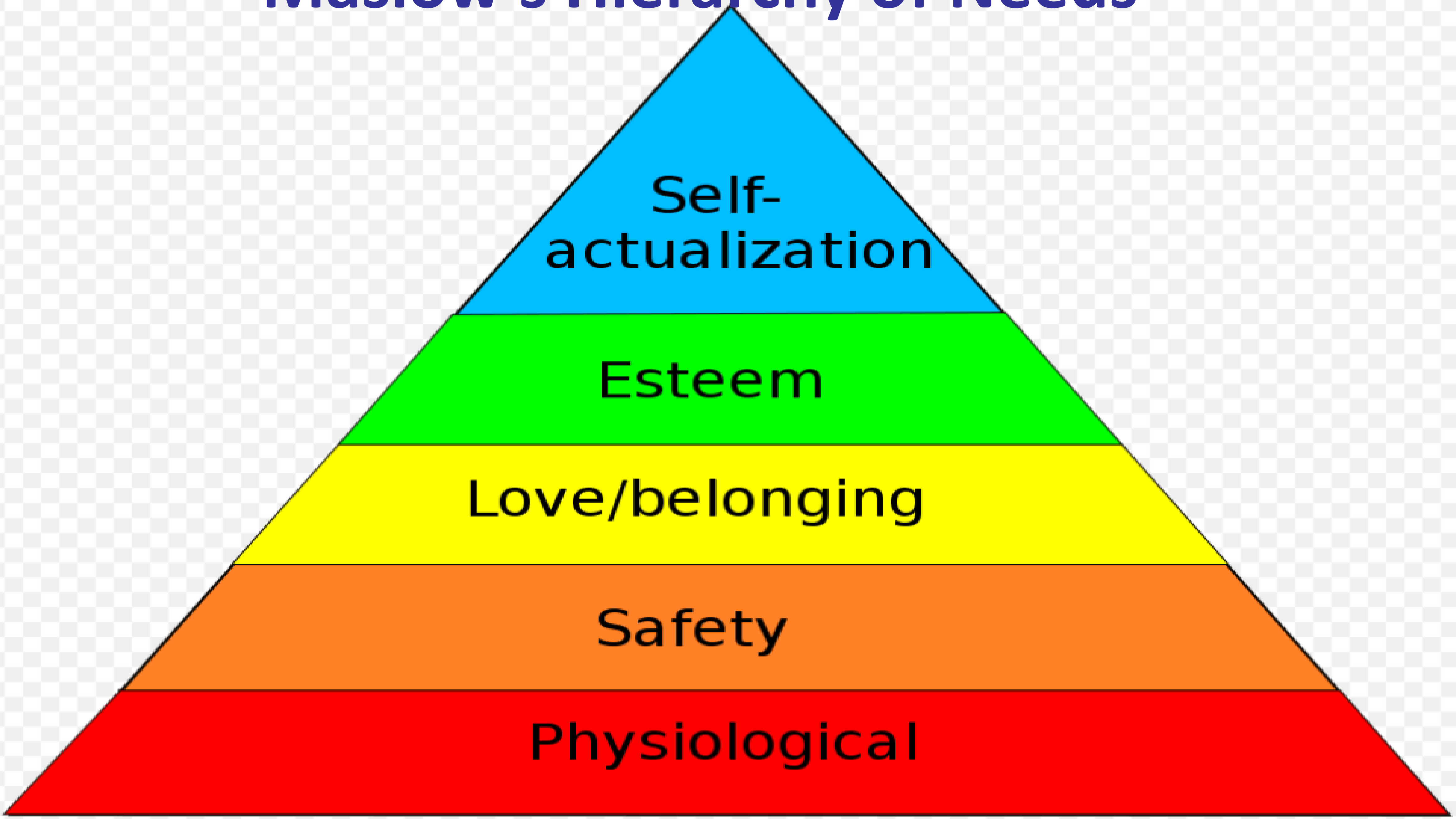
Technion – Israel Institute of Technology

Consultant to the Israeli National Water Authority

Member, Negotiating Team on Water with Israel's Neighbors

Chair, Technical Advisory Committee, World Water Assessment Program

Maslow’s Hierarchy of Needs



The Water Hierarchy: from Science to Society

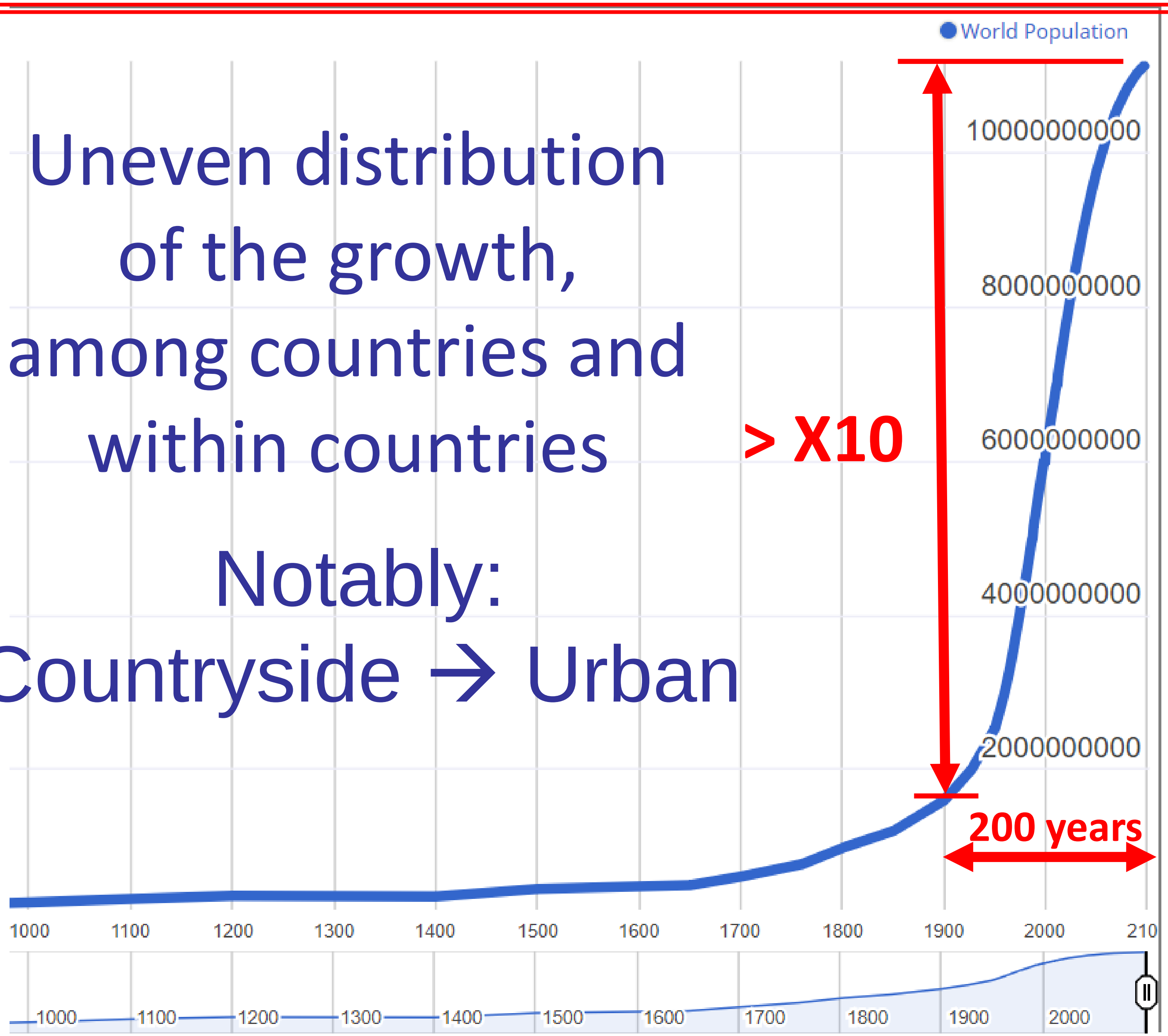
The Water Hierarchy: from Science to Society

Water Sensitive Planning (WSP)

Covers water supply, grey and wastewater collection treatment and reuse, rainwater use, stormwater management, landscaping

Population

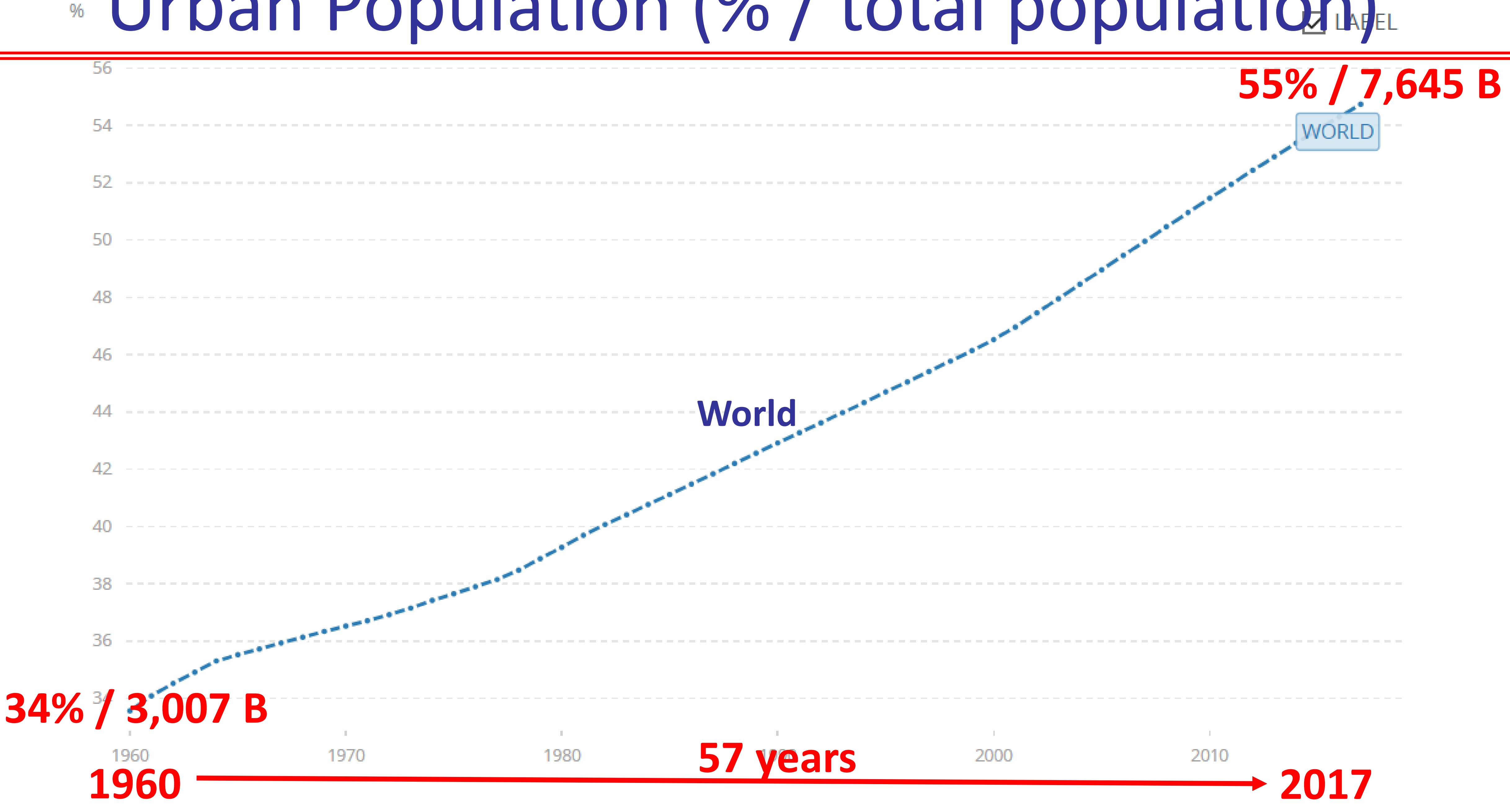
World Population Growth in the past 1,100 Years and in the last 200 Years



Uneven distribution
of the growth,
among countries and
within countries

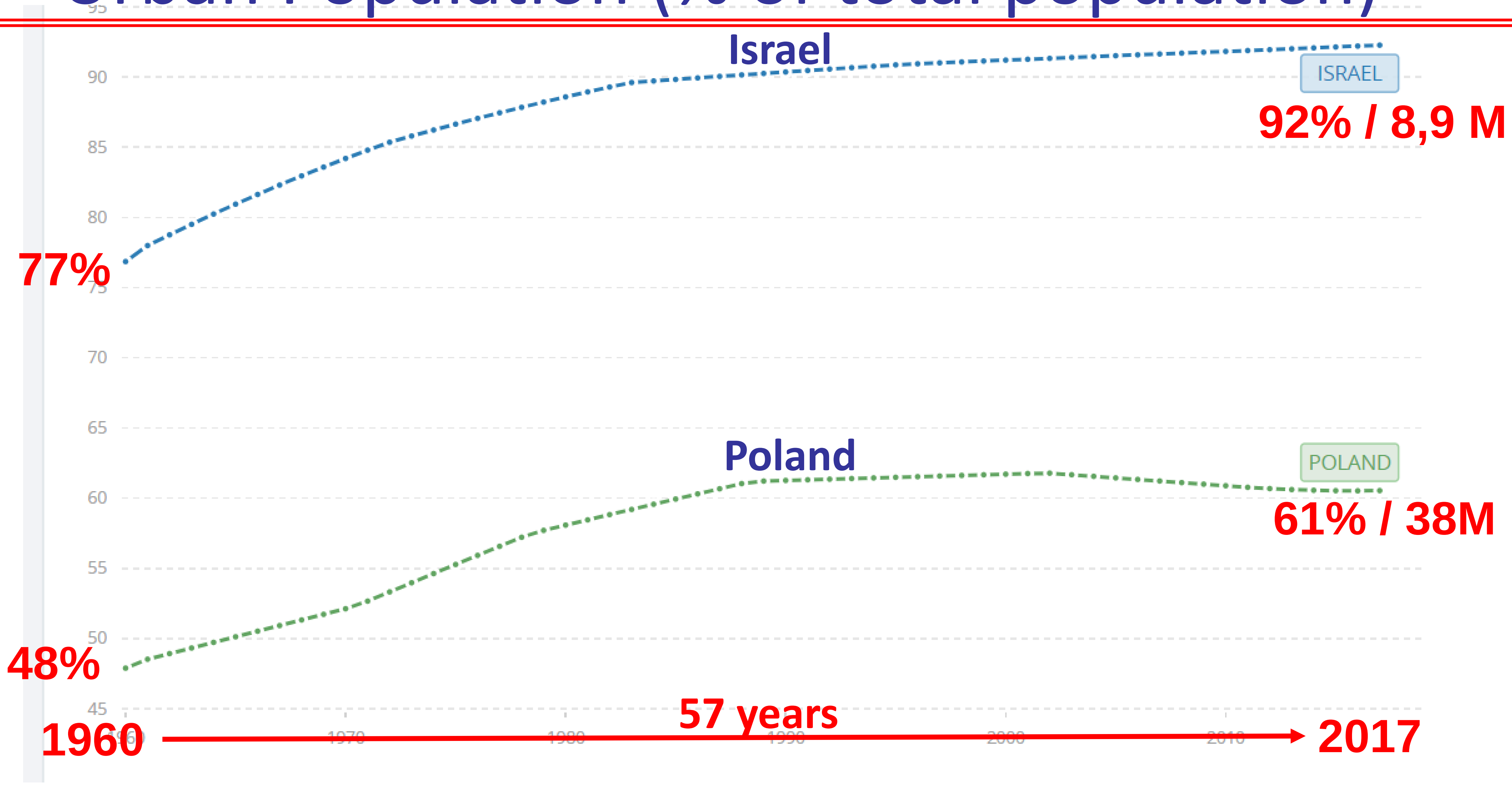
Notably:
Countryside → Urban

Urban Population (% / total population)



https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2017&locations=IL-PL&start=1960&type=points&view=chart

Urban Population (% of total population)



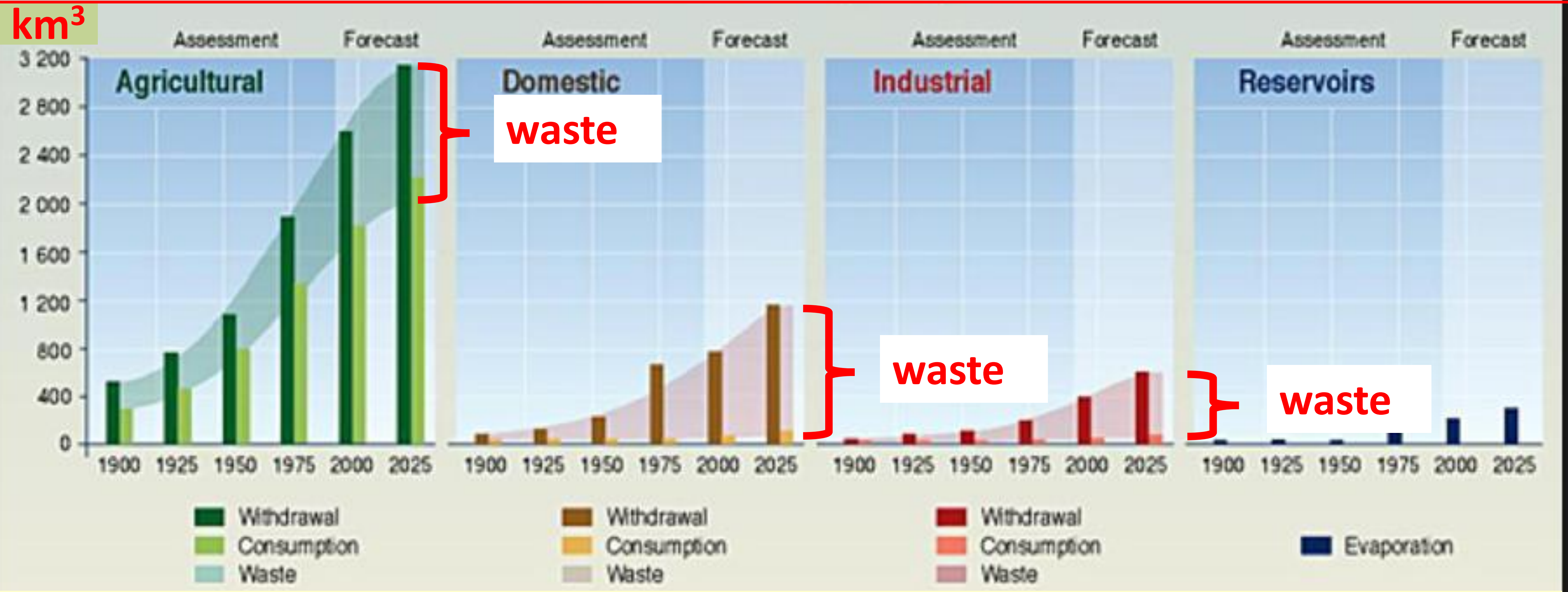
https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2017&locations=IL-PL&start=1960&type=points&view=chart

The most densely populated countries (average)

Rank	Country	Population	Area (km^2)	Density (Pop. per km^2)
1	Singapore	5,612,300	710	7,905
2	Bangladesh	165,000,000	143,998	1,146
3	Taiwan	23,572,415	36,193	651
4	Lebanon	6,093,509	10,452	583
5	South Korea	51,635,256	99,538	519
6	Rwanda	12,001,136	26,338	456
7	Netherlands	17,250,000	41,526	415
8	Haiti	11,112,945	27,065	411
9	India	1,335,500,000	3,287,240	406
10	**Israel**	8,900,000	22,072	**403**
91	**Poland**	38,096,850	312,679	**122**

Water Sources and Uses

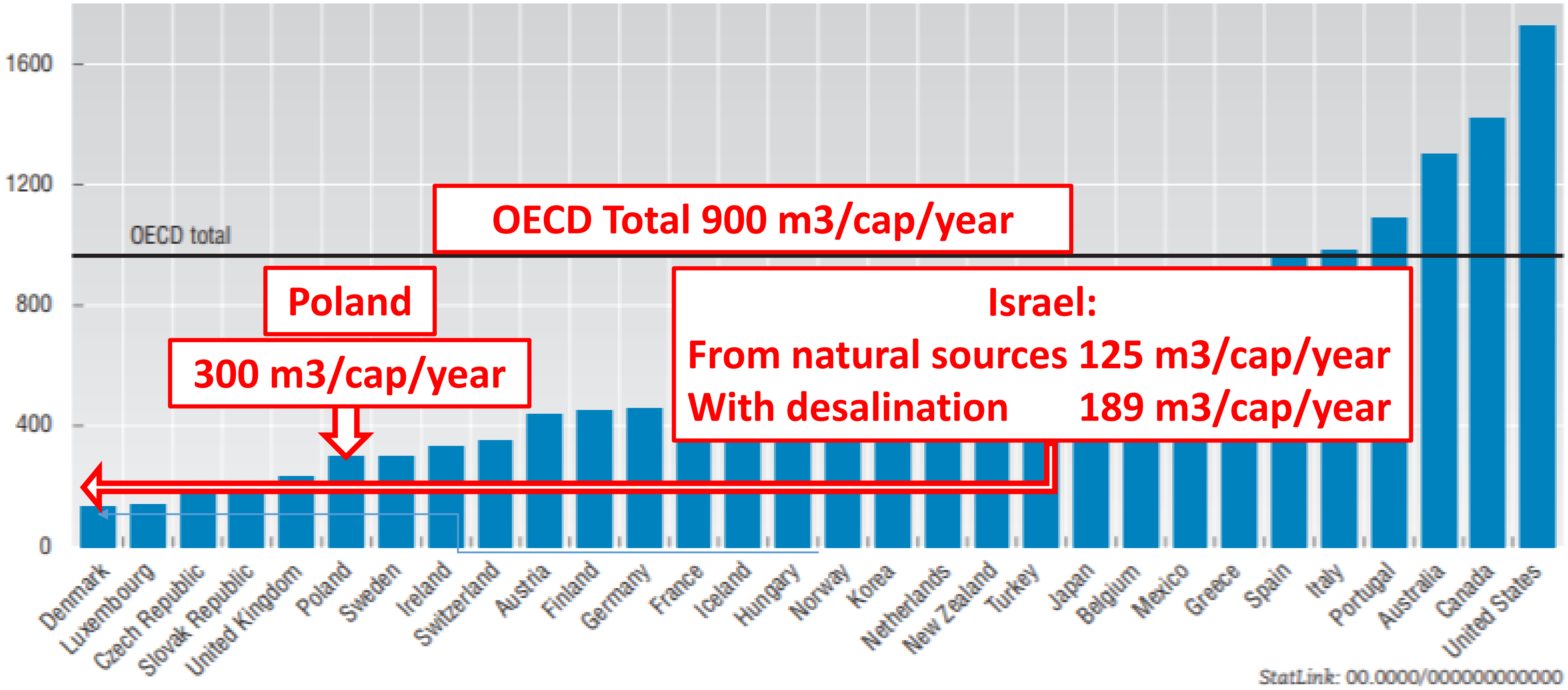
Evolution of Global Water Use
Withdrawal, Consumption and Waste by Sector



Domestic water consumption in developed countries (500-600 litres per capita per day)
Is about six time greater than in developing countries (60-150 litres per capita per day)

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999

Water abstractions: OECD, Poland, Israel
(m3/cap/year) (2002 or latest data)



http://www.oecd.org/publications/factbook/34416097.pdf

Poland: Water Infrastructure and Consumption (2017)

Statistics Poland: Water supply system and sewage management in Poland in 2017, Table 2

Specification	2016	2015 = 100	2017	2016 = 100
Distribution water supply network in thous. km (as of December 31st)	301.0	101.0	303.9	101.0
Distribution water supply network for 100 km^2	96.3	101.0	97.2	100.9
Connections to residential buildings in thous. pcs	5576.2	101.8	5647.3	101.3
Water consumption in households in hm^3	1238.1	100.1	1223.6	98.8
Average water consumption per capita (m3/year)	**32.2**	100.0	**32.2**	98.8

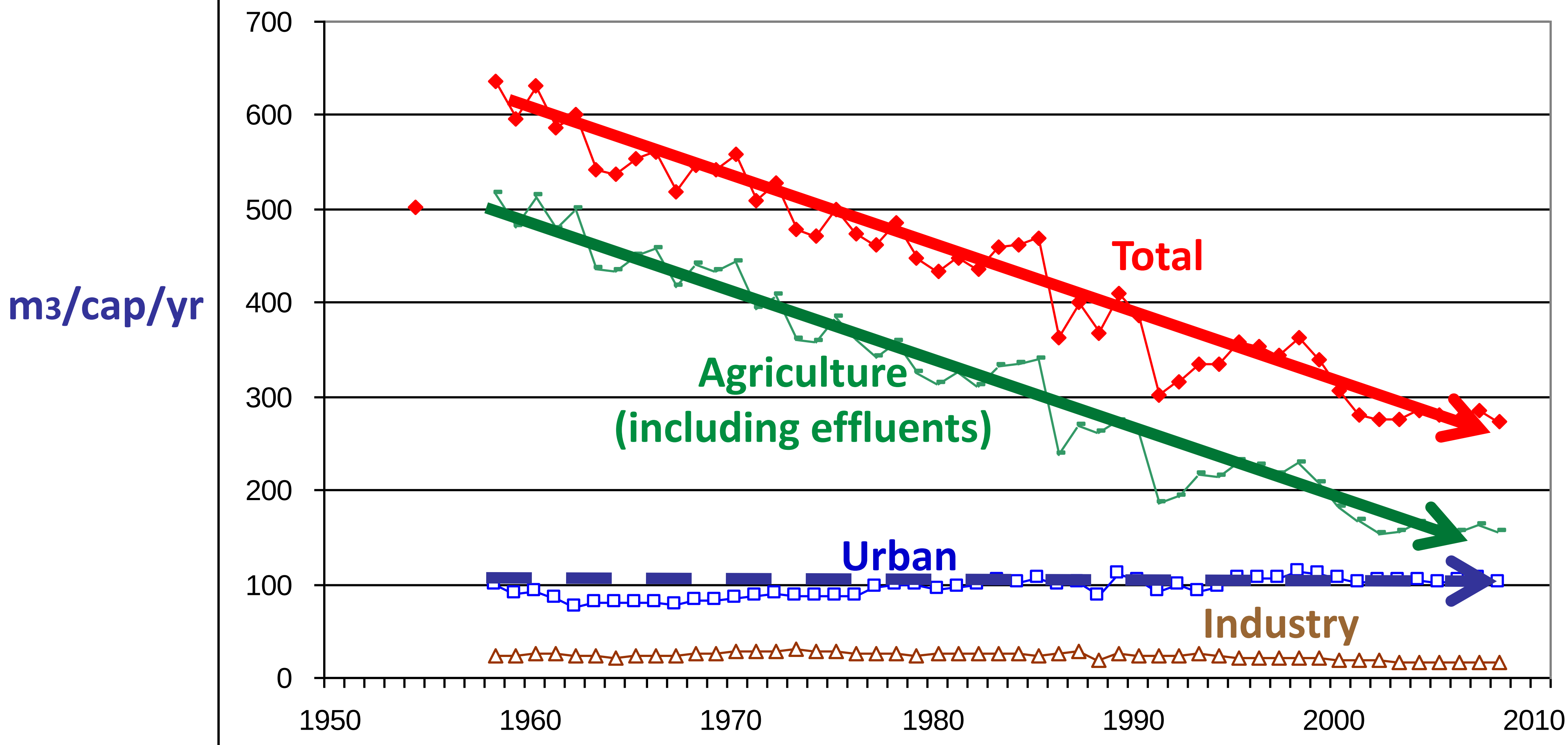
Per capita: average decrease 2016 to 2017 0.4 m^3/cap/year, in rural areas 0.7 m^3/cap/year

Total decreased by 1.2%, from 1,238.3 hm^3 (2016) to 1,223.6 hm^3 (2017)

Demand Management

Israel's per capita water consumption (m3/cap/year)

Including use of treated effluents in agriculture



Source: the late Prof. Yoav Kislev

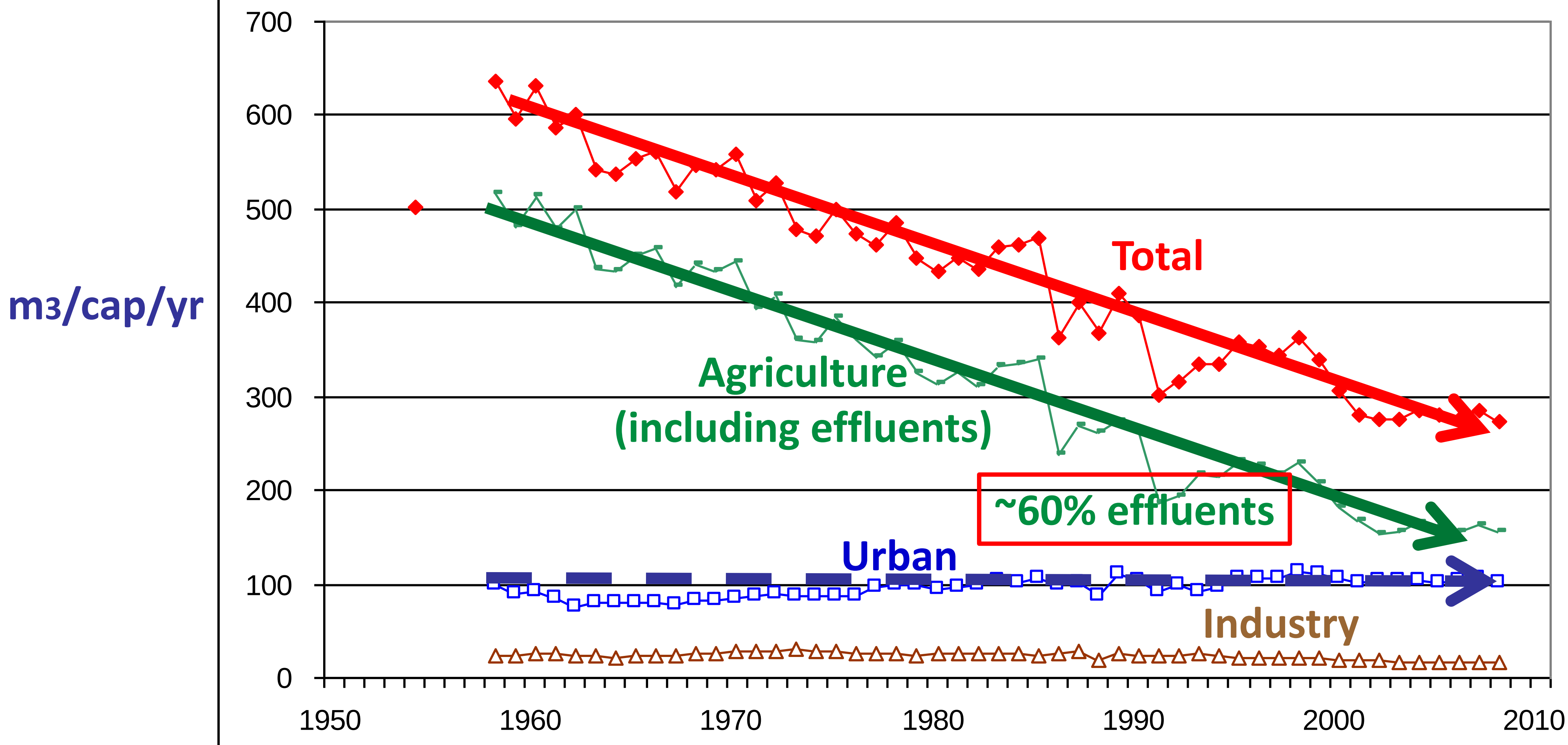
Demand Management – from Agriculture to the Cities

While **>70%** of all water supplies go to agriculture, it is imperative to reduce water use for irrigation – while increasing crop yields and crop value

Therefore: an important component of the national water resources management policy must be efficiency of water use in agriculture
→leaving more for the cities & to nature/env.

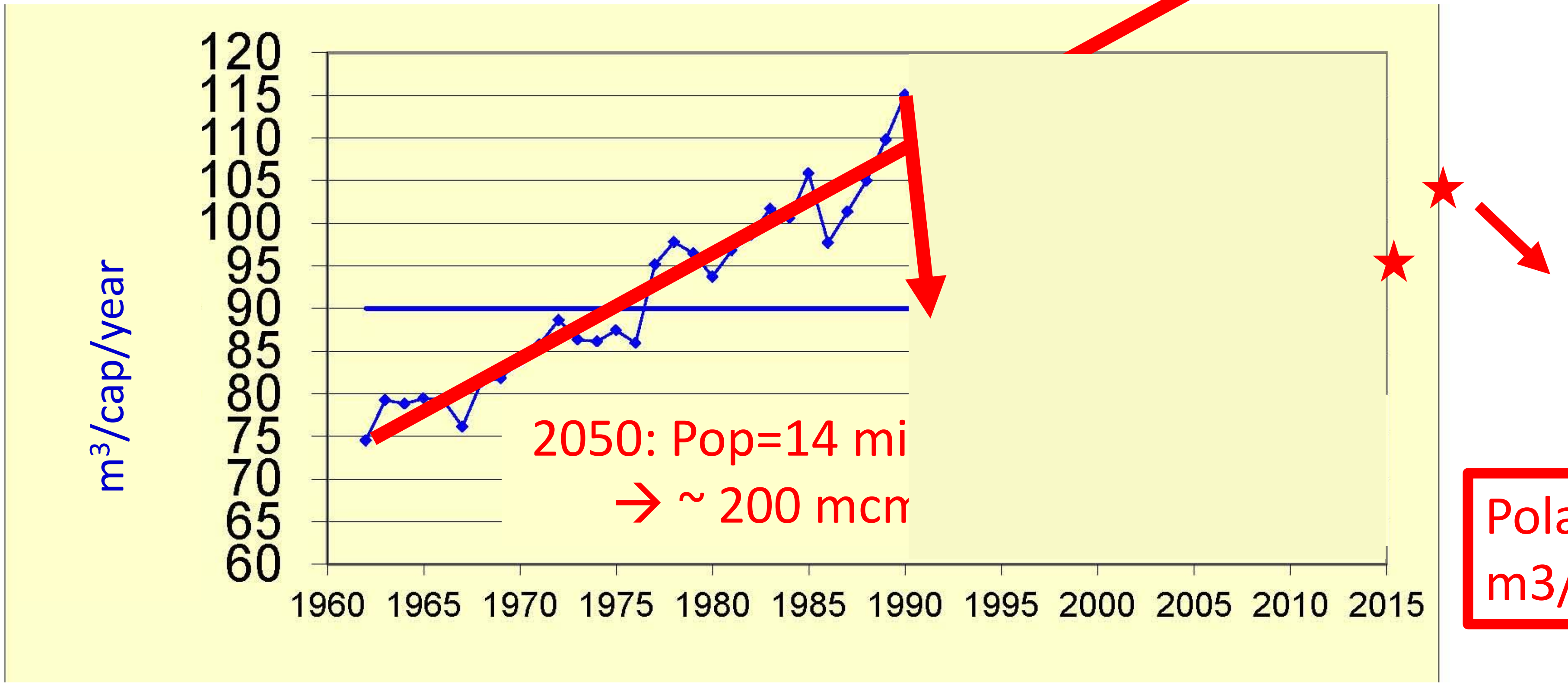
Israel’s per capita water consumption (m3/cap/year)

Including use of treated effluents in agriculture



Source: the late Prof. Yoav Kislev

Urban per capita water consumption in Israel (m3/cap/year) 1962-2018 & a look ahead



2018 public campaign

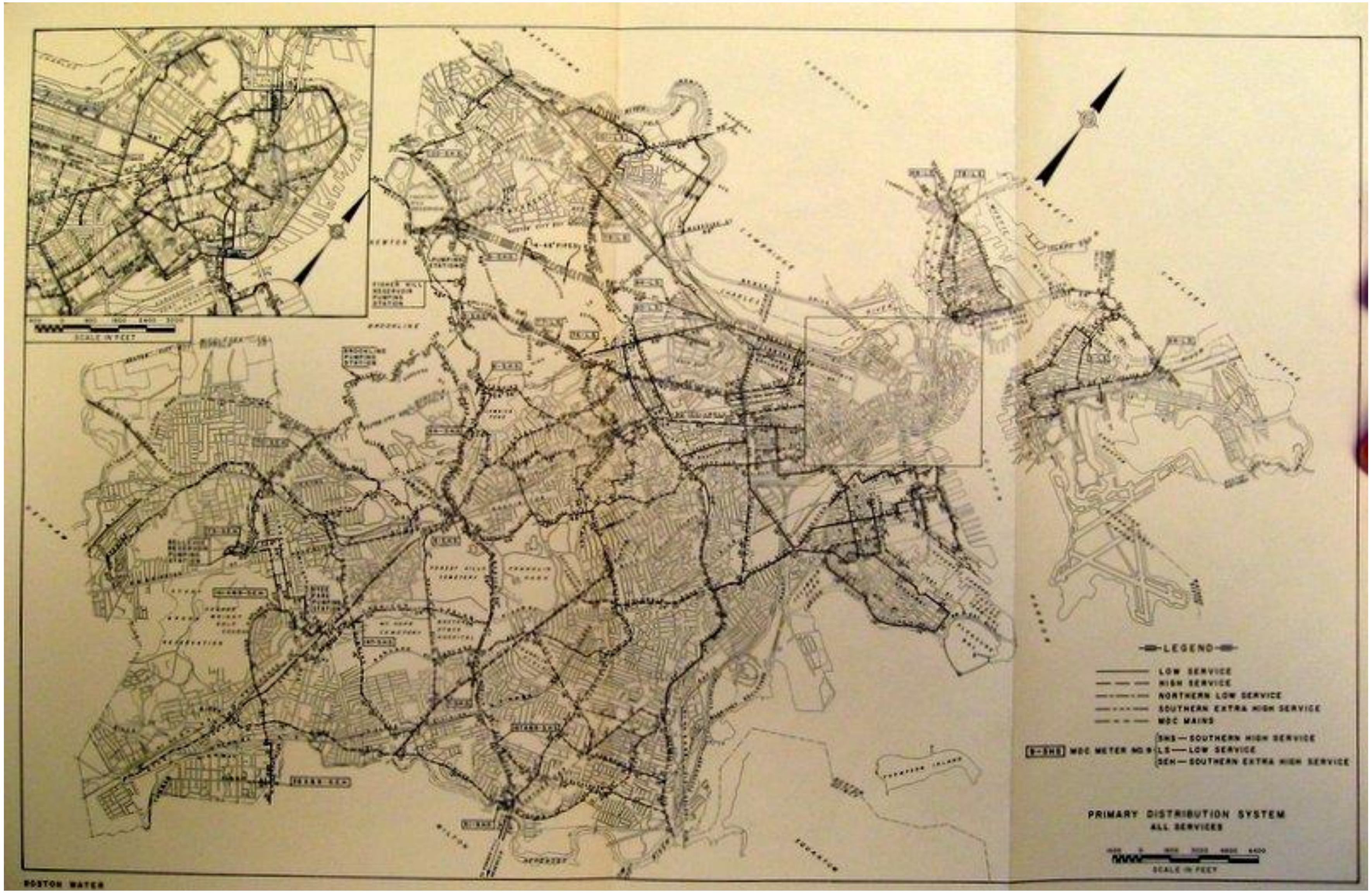
Poland: 31.8 m3/cap/year

Total national average annual fresh water = 1,100 mcm/year

Desalination capacity in 2018 = 585 mcm/year

Water Distribution Systems Management

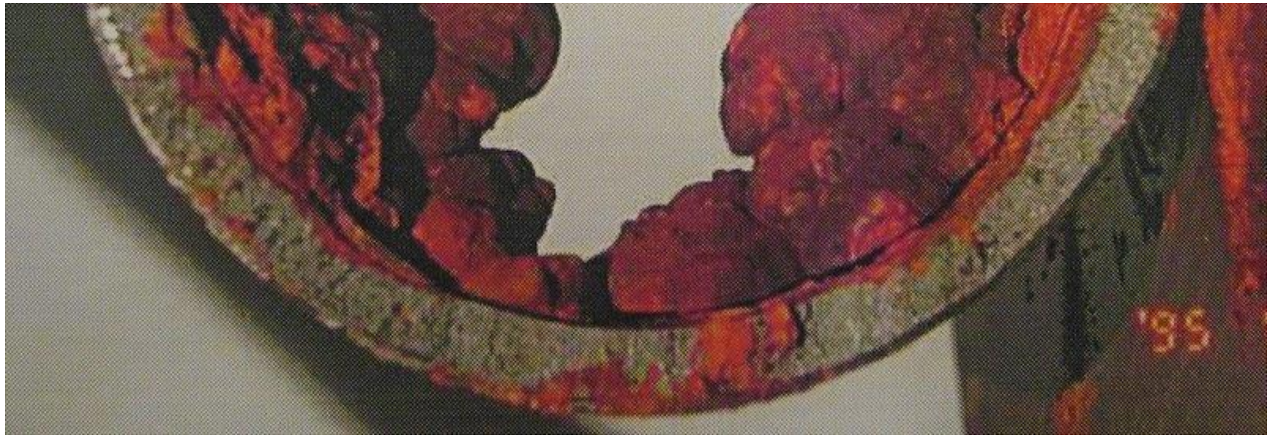
Upgrading the Boston primary distribution system



Charles A. Maguire & Assoc., 1968

Upgrading the Boston primary distribution system

By cleaning and lining the deteriorated pipes



Charles A. Maguire & Assoc., 1968

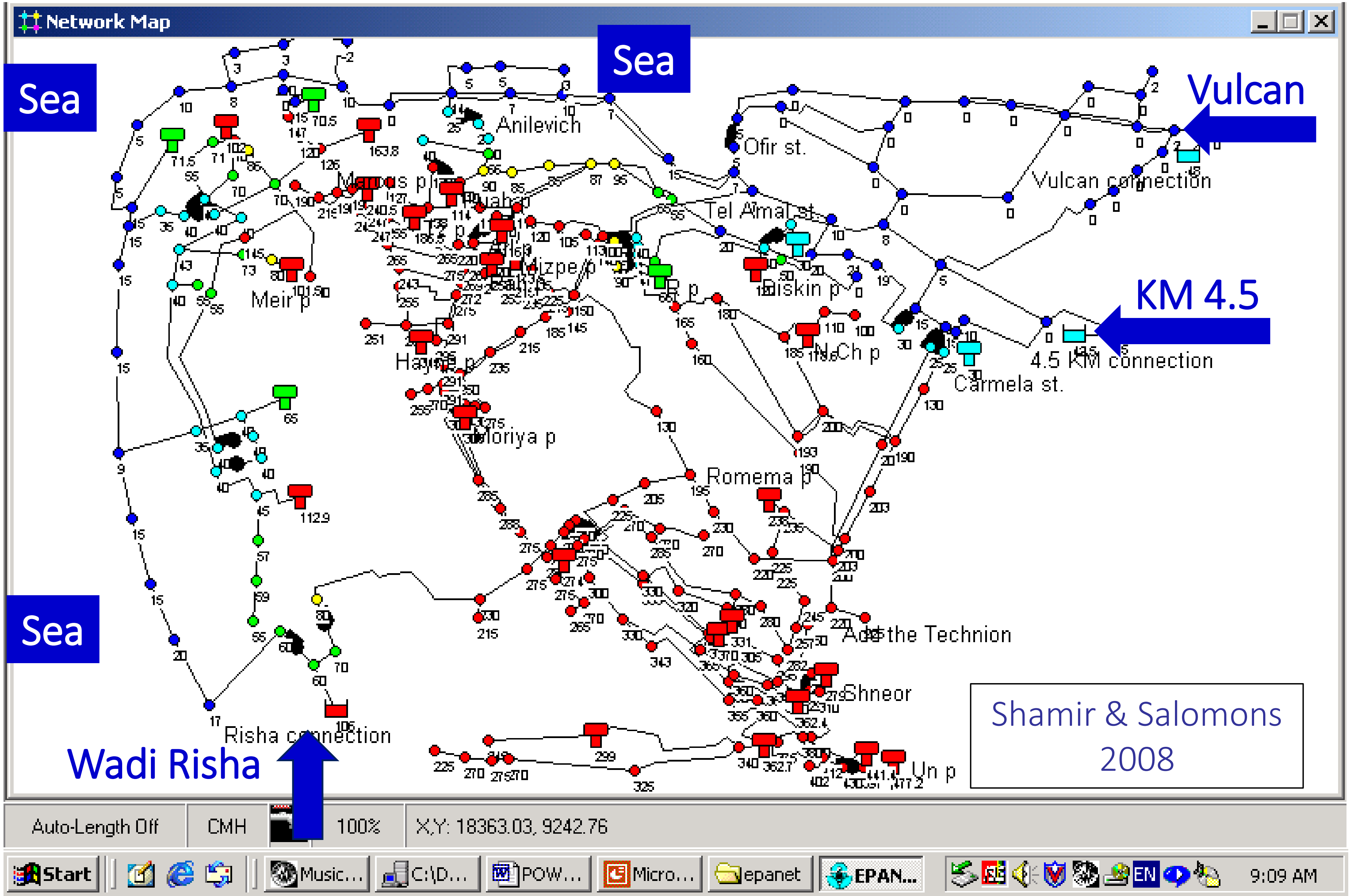
Water Distribution Optimal Operation

Optimal operation of the Haifa system

Elevations - sea-level to +500 m
with ~100 pressure zones

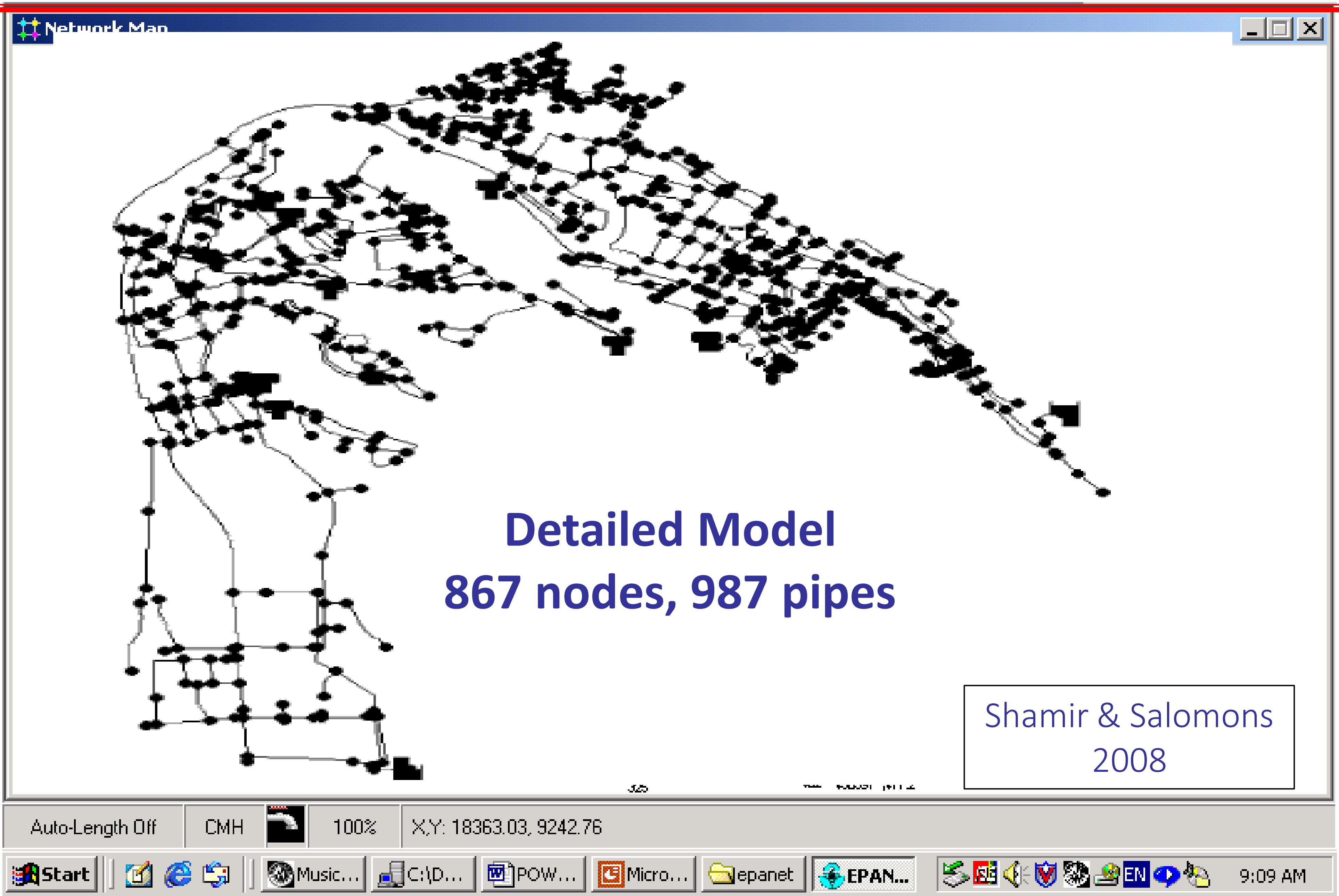
Shamir & Salomons, JWRPM, 2008

Optimal operation of the Haifa system

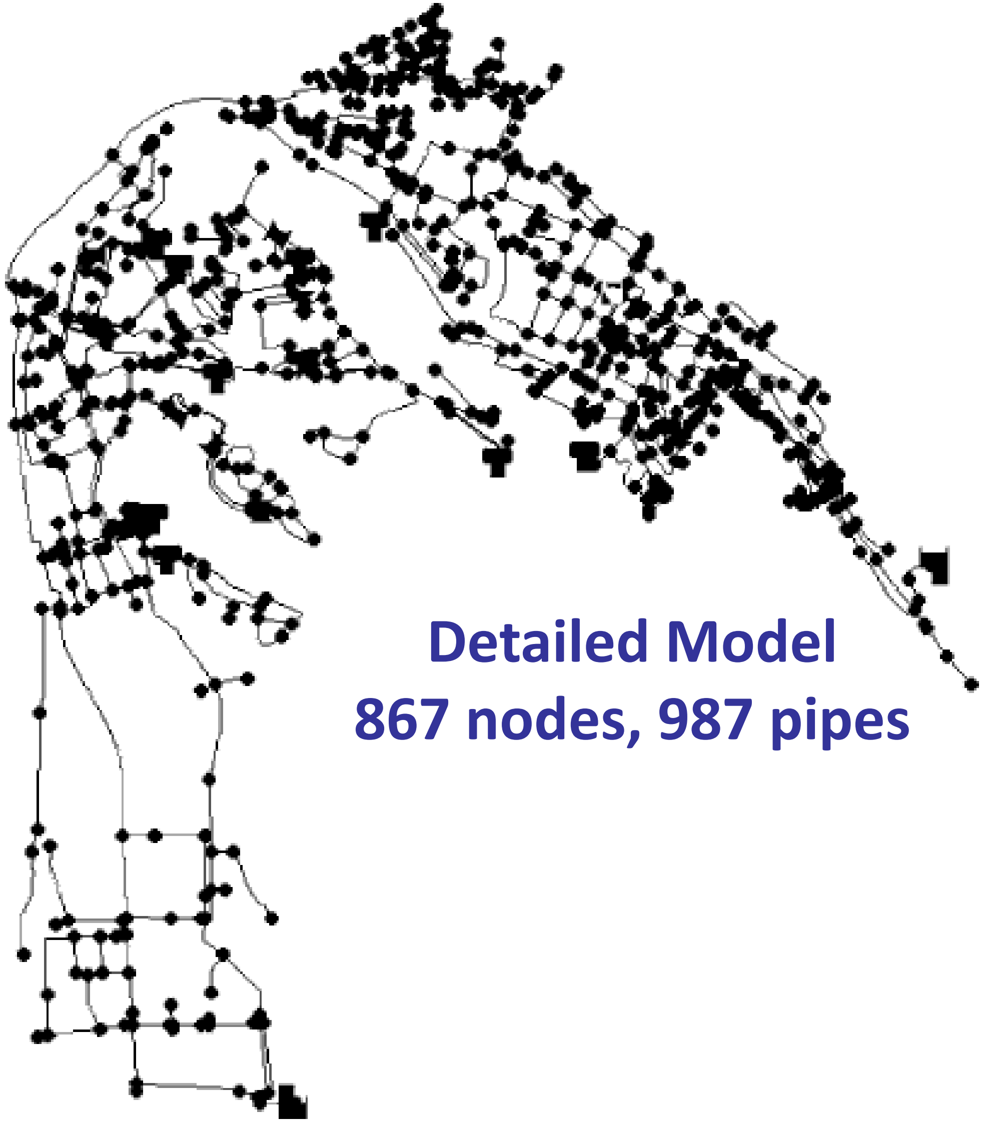


Shamir & Salomons 2008

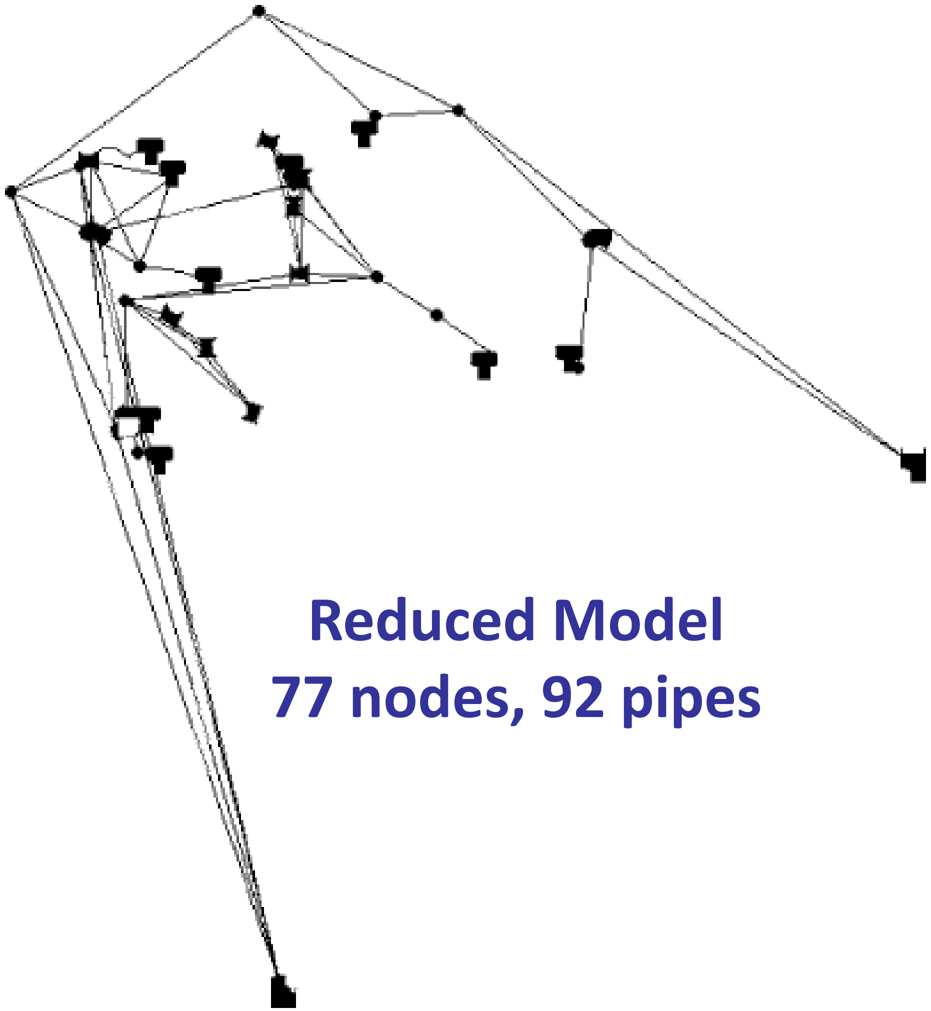
Reduced model for optimization of operation



Reduced model for optimization of operation



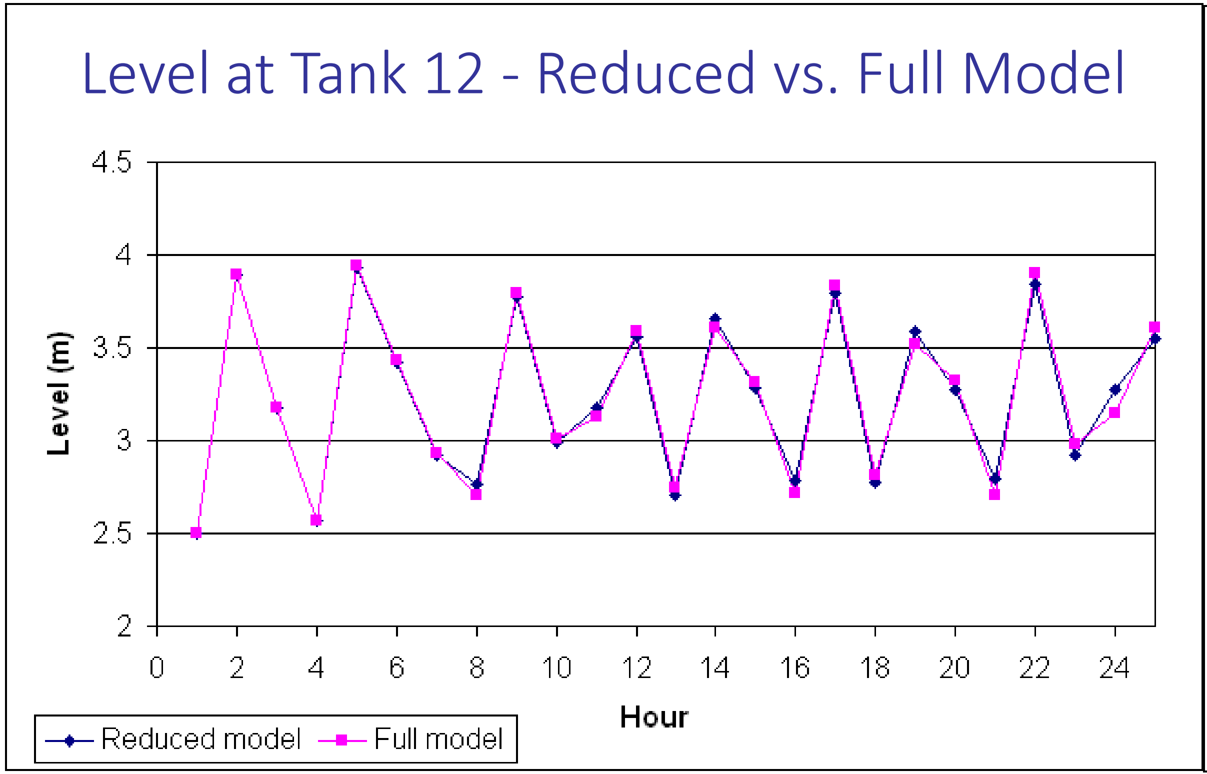
Detailed Model
867 nodes, 987 pipes

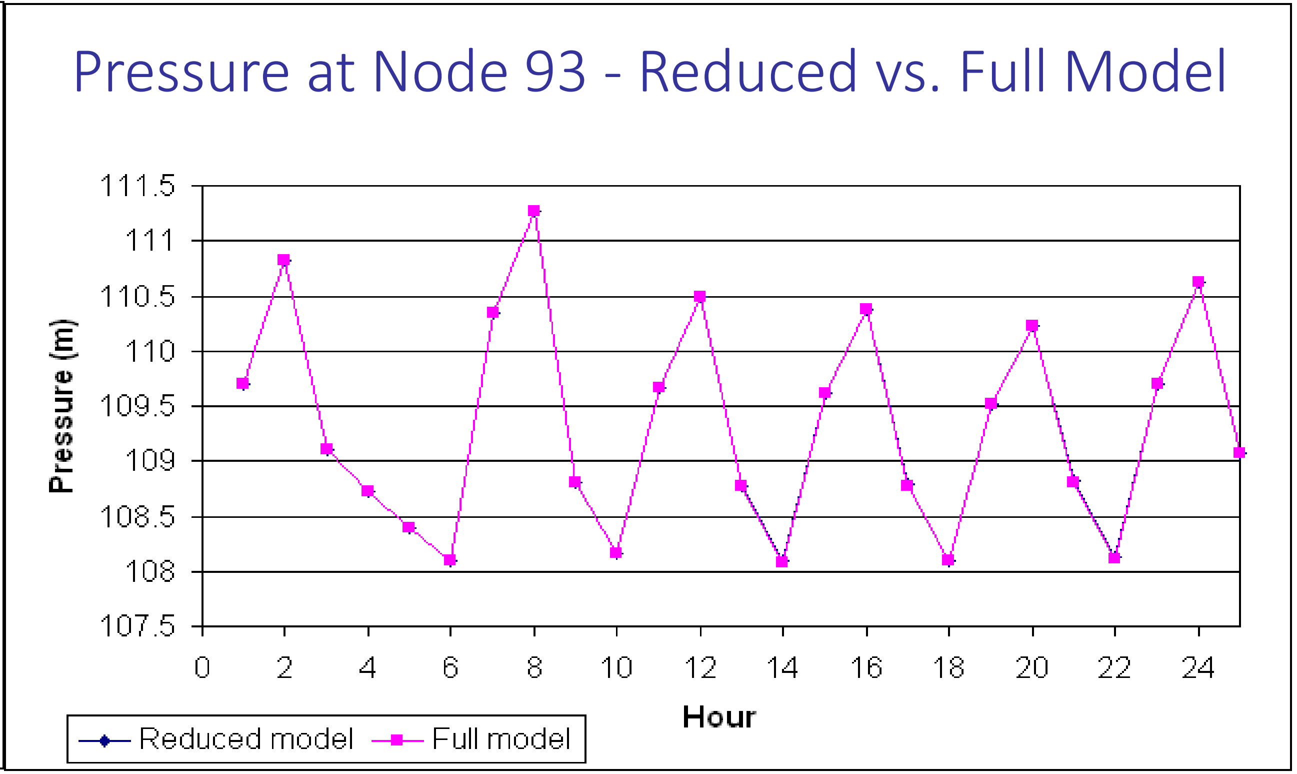


Reduced Model
77 nodes, 92 pipes

Shamir & Salomons, JWRPM, 2008

Comparison of results of reduced and full model



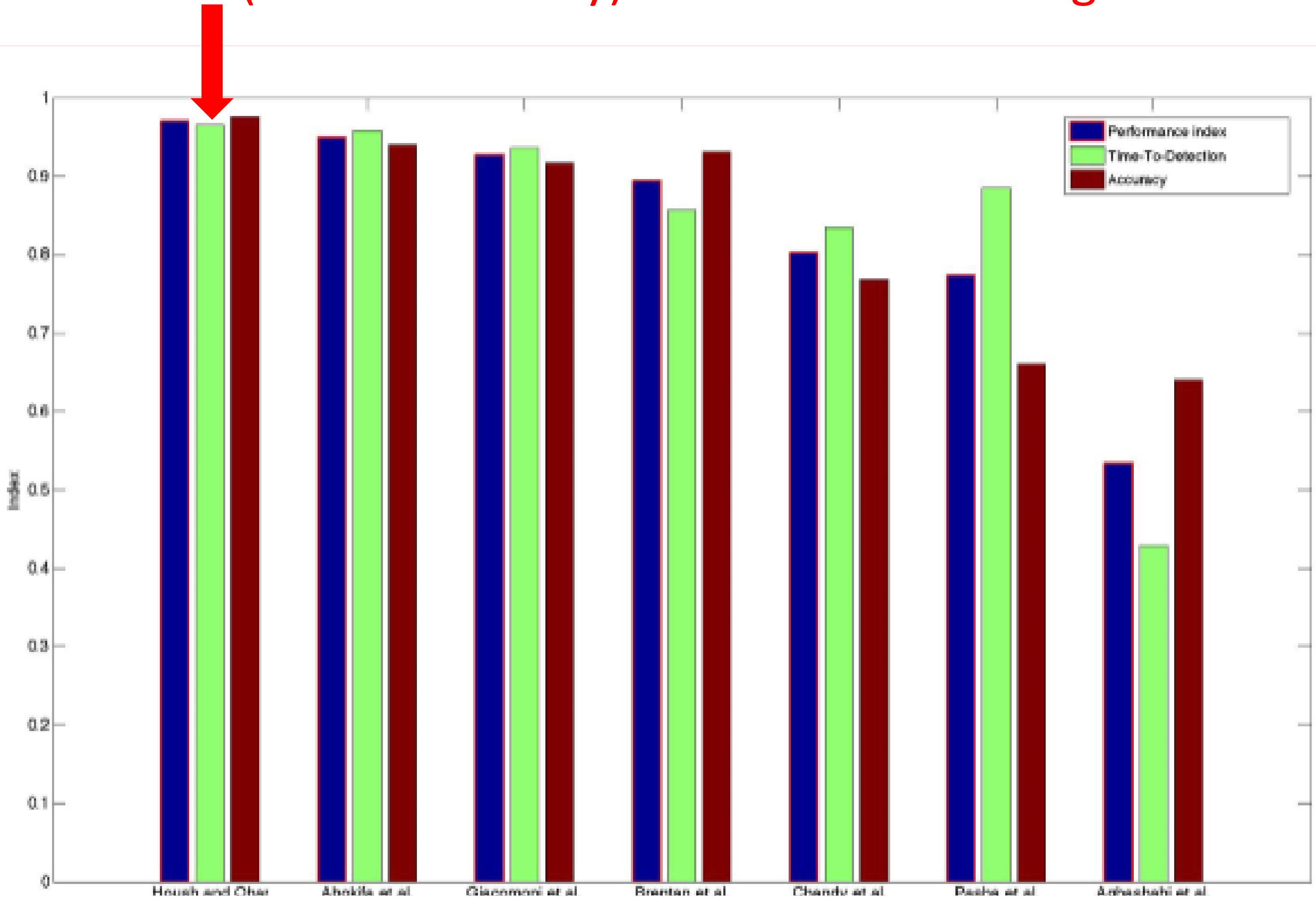


Shamir & Salomons, JWRPM, 2008

Water Distribution Cyber Protection

BATADAL (2017) = BATtle of the Attack Detection Algorithms (https://batadal.net)

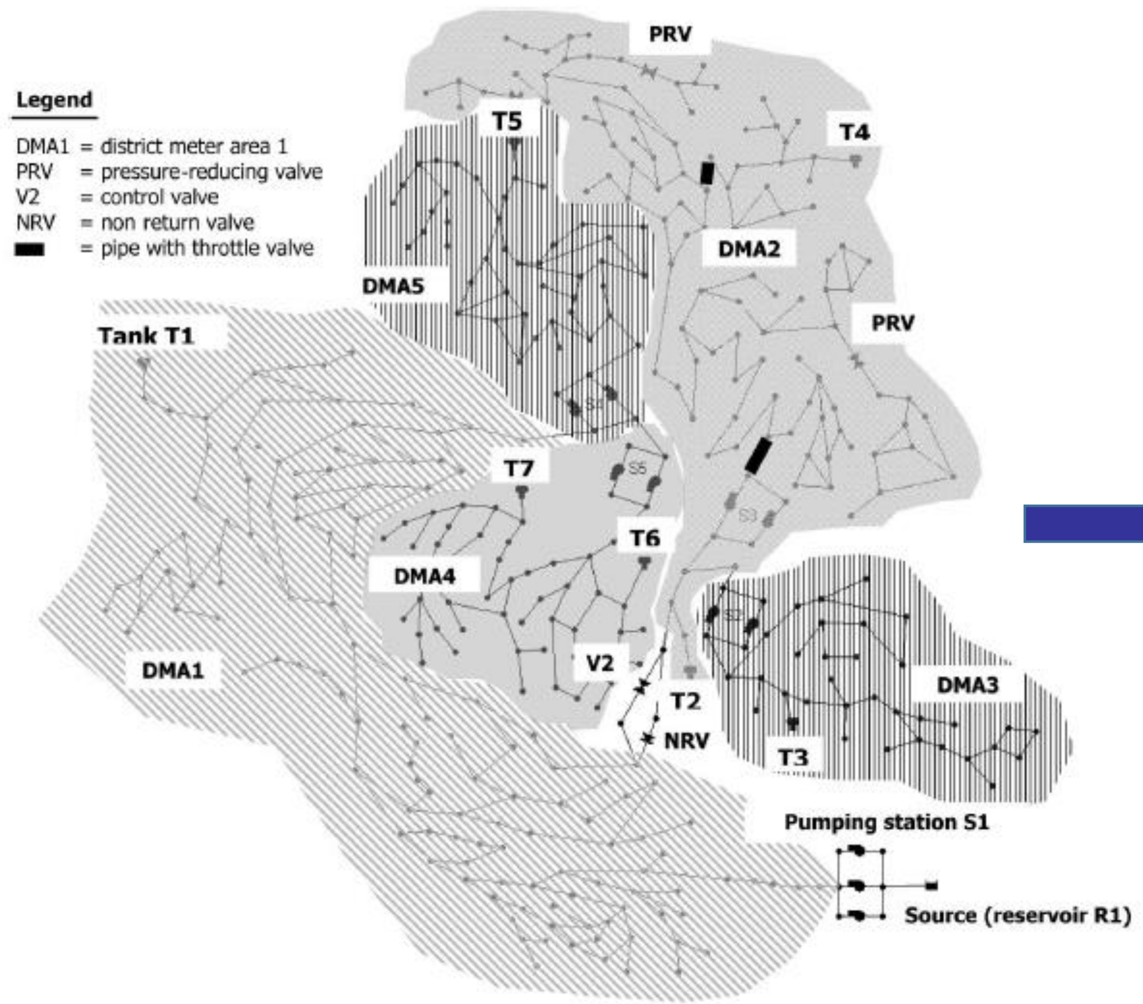
Winners: Mashor Housh (Haifa University) and Ziv Ohar – Using a **Model-Based Approach**



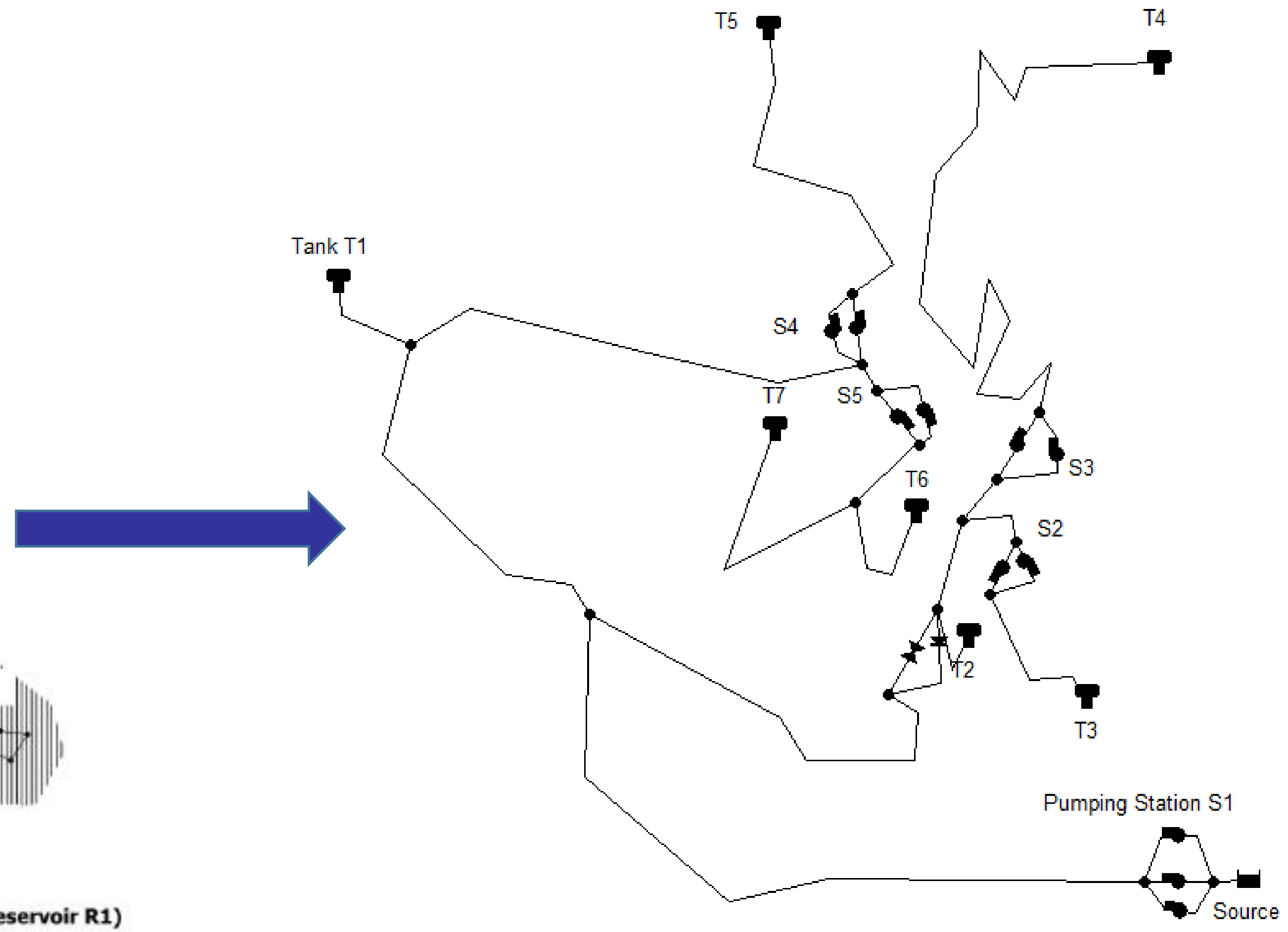
Housh, M. & Ohar, Z. (2017) Model Based Approach for Cyber-Physical Attacks Detection in Water Distribution Systems. *World Environmental Water Resources Congress*, ASCE, Reston, VA, USA

BATADAL – Battle of Detecting Cyber-Physical Attacks

Full Model



Reduced/Aggregate Model



Technologies for Water Systems

HYDRANTECH

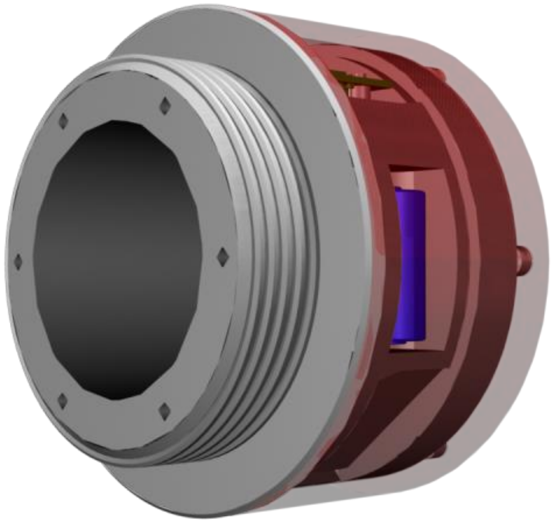
PARAMETER
Technologies Ltd

A System for the Monitoring and Protection of Hydrants

PETENT PENDING
APPLICANT NUMBER: 62/252,730

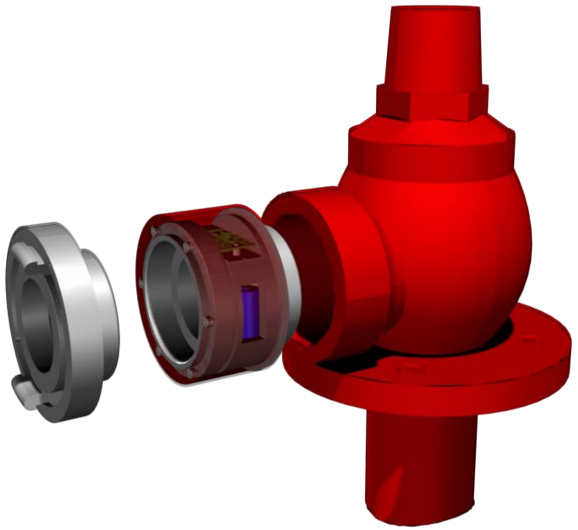
https://www.youtube.com/watch?v=yWJb0V3KgNE

The device is based on an **electronic bracelet** which is easily installed on the hydrant, requires no special training, and is relatively inexpensive compared to existing solutions. The solution creates an "identity card" for each municipal hydrant allowing the hydrants' activities to be monitored.



HYDRANTECH

The system assesses the amount of water flowing from the hydrant. It also enables real-time detection of the hydrant’s activities when fluids are flowing from or penetrating into the hydrant.



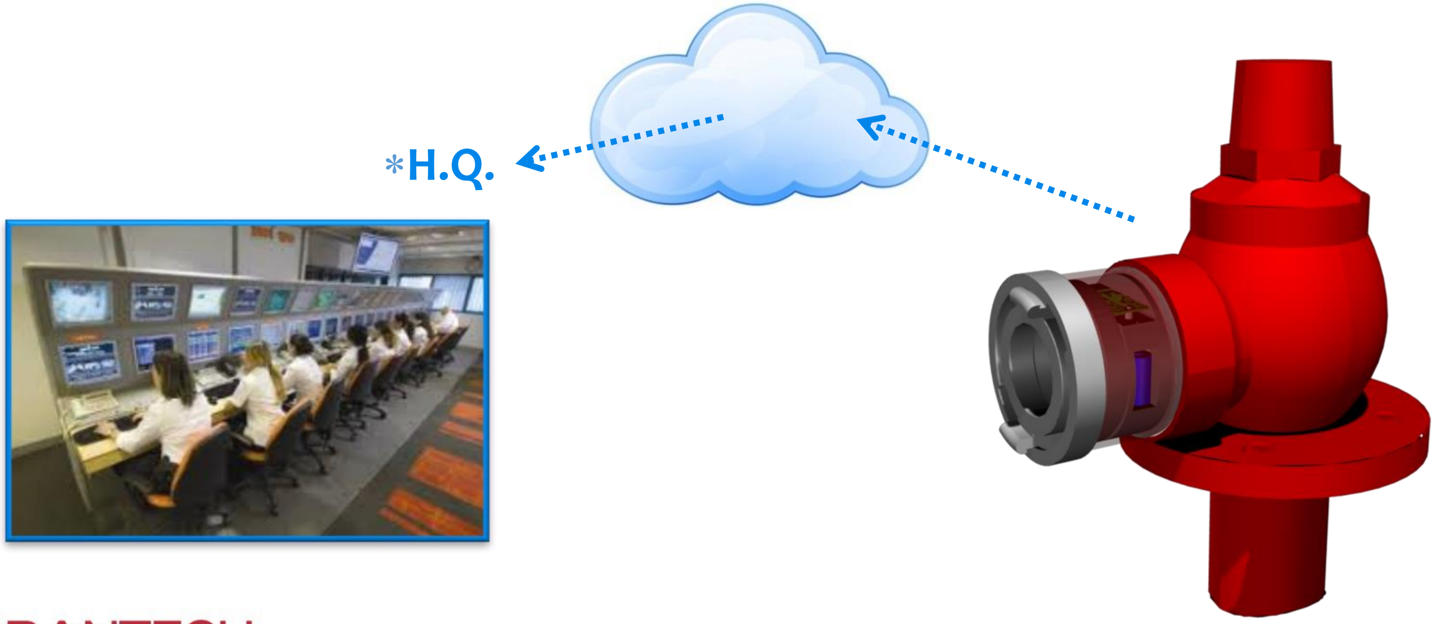
HYDRANTECH

Each hydrant is equipped with a “smart bracelet” that communicates wirelessly with the municipal command center, mapping the hydrants scattered throughout the city.
Warnings can be sent to a mobile phone by means of an app.

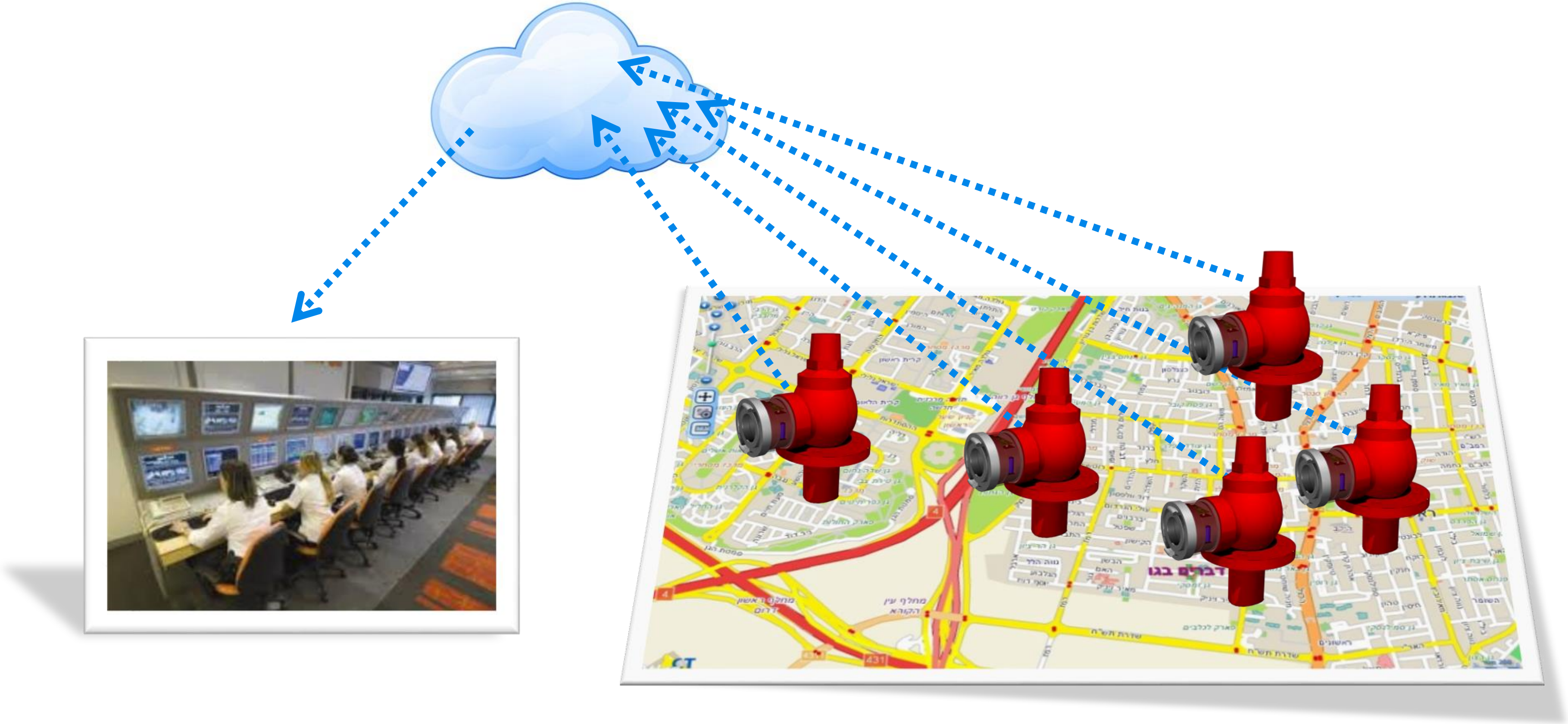
HYDRANTECH

Real Time information:
Location of the hydrant, Flow out, Flow in

In continuous contact with the management software
and thru it, the municipal headquarters



HYDRANTECH



HYDRANTECH

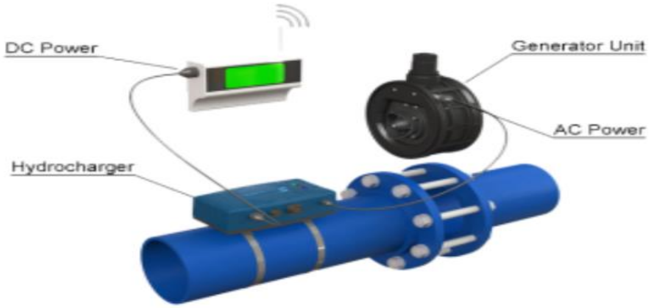
HydroSpin

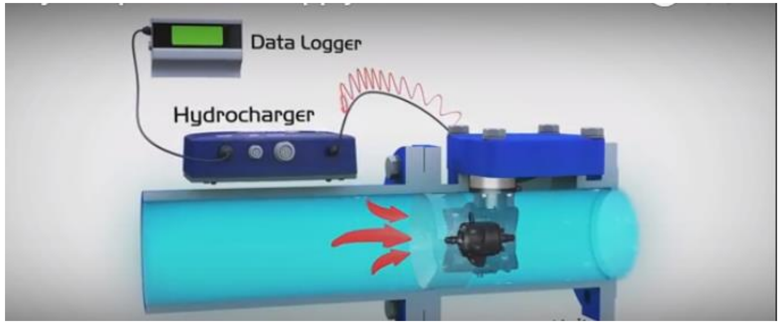
Electric generators using in-pipe flow, for powering probes, monitors, transmitters and data loggers

http://www.h-spin.com/solutions/

For 6” and 8” (150mm and 200mm) Diameter Pipes

For 6” and 8” (150mm and 200mm) Diameter Pipes

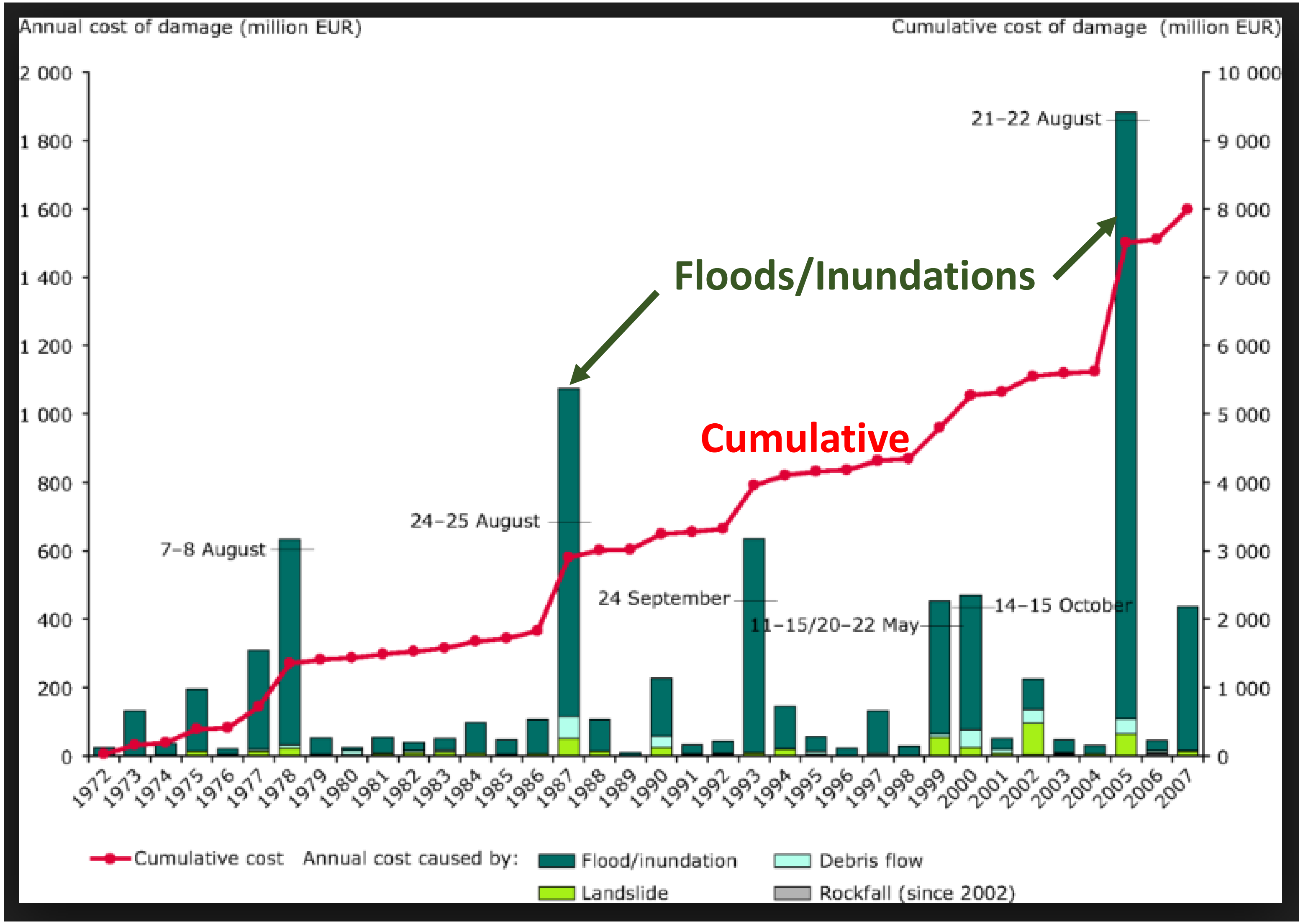




Hydro Generator Swing Unit

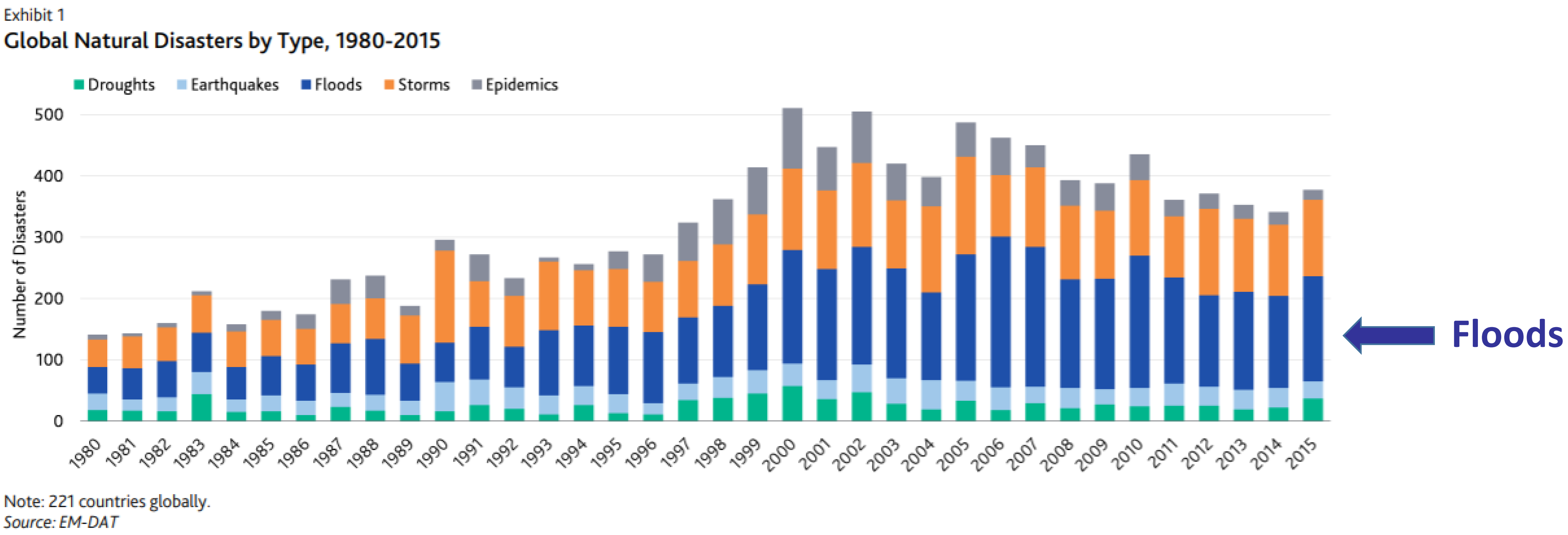
Floods and Flood Damages

EU annual damage cost (10^6 Euro)



Source: European Environment Agency

Number of global natural disasters, 1980-2015



Moody's Investor Service, 28 November 2016

https://www.eenews.net/assets/2016/11/30/document_cw_01.pdf

Stormwater Management

Other terms, not exactly the same objectives

LID = Low Impact Development (USA)

WSUD = Water Sensitive Urban Design (Australia)

SUDS = Sustainable Drainage Systems (UK)

Stormwater Management

While the objectives are location-specific
the list of "soft/green" and "hard/grey"
Best Management Practices (BMPs) are similar

Stormwater Management, Urban and Regional(*)

- The new stormwater paradigm: it is a resource, not merely a nuisance & threat
- Four groups of objectives, to be addressed simultaneously and synergistically:
  - Hydrological: added water supplies, flood control
  - Economic: lower flood damages, lower system costs
  - Environmental: enhanced environmental amenities
  - Social: advance social norms and awareness, engage the community
- The mix/balance of objectives is location specific: climate, precipitation, soils, land cover, built areas, receiving waters, economics, social norms, for example:
  - Protect quality in the receiving waters - stream, river, lake, sea, groundwater
  - Add water for on-site uses – irrigation, landscaping, groundwater recharge
  - Mitigate downstream flooding damages by reducing runoff discharge

(*) Naomi Carmon & Uri Shamir, "Water-sensitive planning: integrating water considerations into urban and regional planning", *Water and Environment Journal* 24 (2009) 181–191

Stormwater Management, Urban and Regional(*)

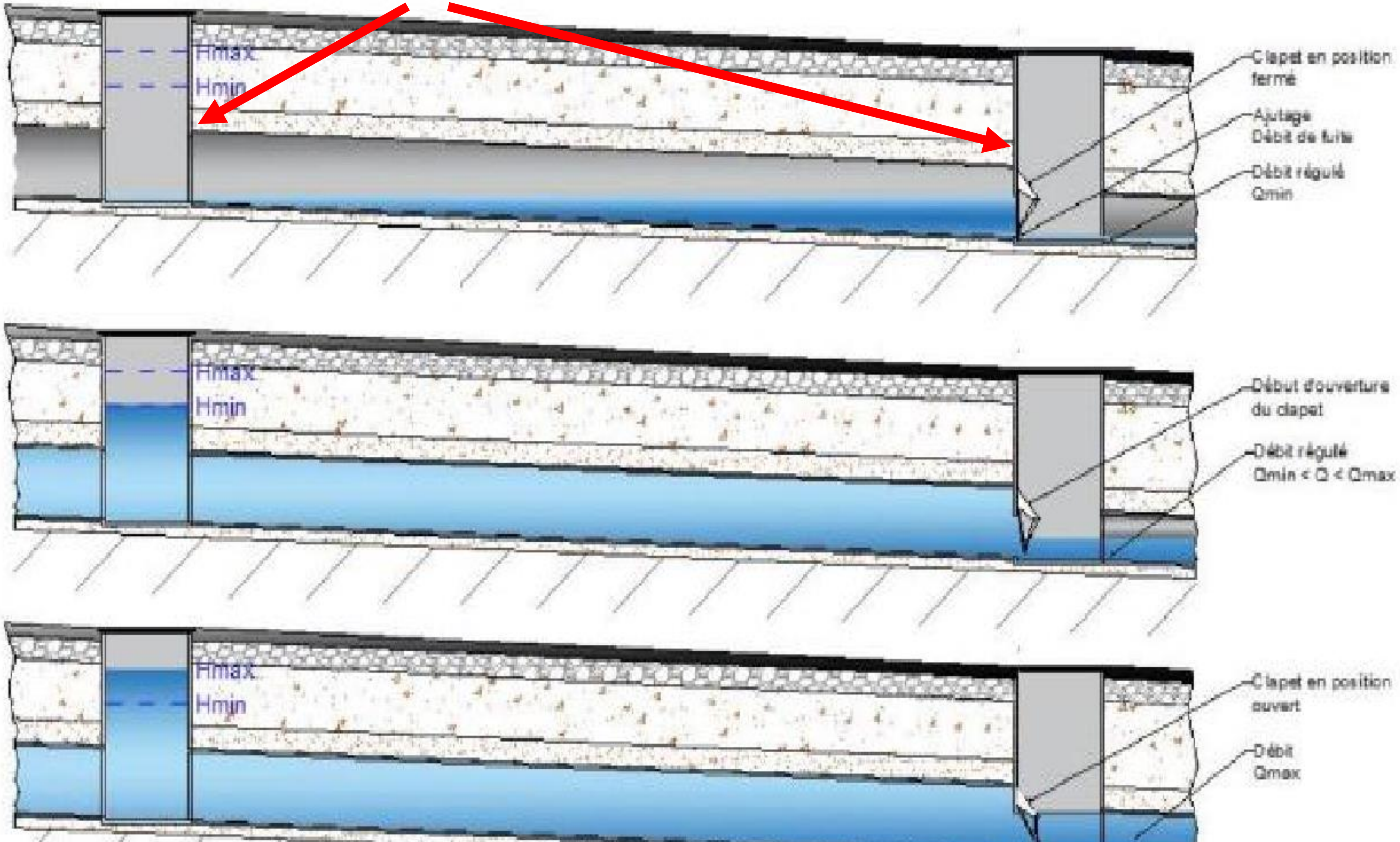
- Best Management Practices (BMPs):
  - BMPs I: urban land use practices - spatial planning, placement and design of open spaces and roads, follow the natural hydrology
  - BMPs II: land cover design: pervious sidewalks and roads, green roofs, pervious gardens, modified topography, depressions, raingardens, vegetation
  - BMPs III: constructed facilities
- Regional WSP: Catchment area master plan, delineation of floodplains, urban-regional coordination
- Legal and statutory frameworks
- Enabling:
  - Training the relevant professionals in the spirit of WSP and interdisciplinary cooperation
  - Economic incentives
  - Public–Civic Partnerships (PCPs) and public–private partnerships (PPPs)

BMPs

Best Management Practices

Real Time Control (RTC) of urban drainage systems

Use the storage capacity of the drainage system to control the outflows
Using remotely controlled gates, under operational optimization software



Real Time Control (RTC) of urban drainage systems

Nanna Hoegh Nielsen, Camille Ravn & Nikolaj Molbye ”Implementation and design of a RTC strategy in the sewage system in Kolding, Denmark”, NOVATECH 2010

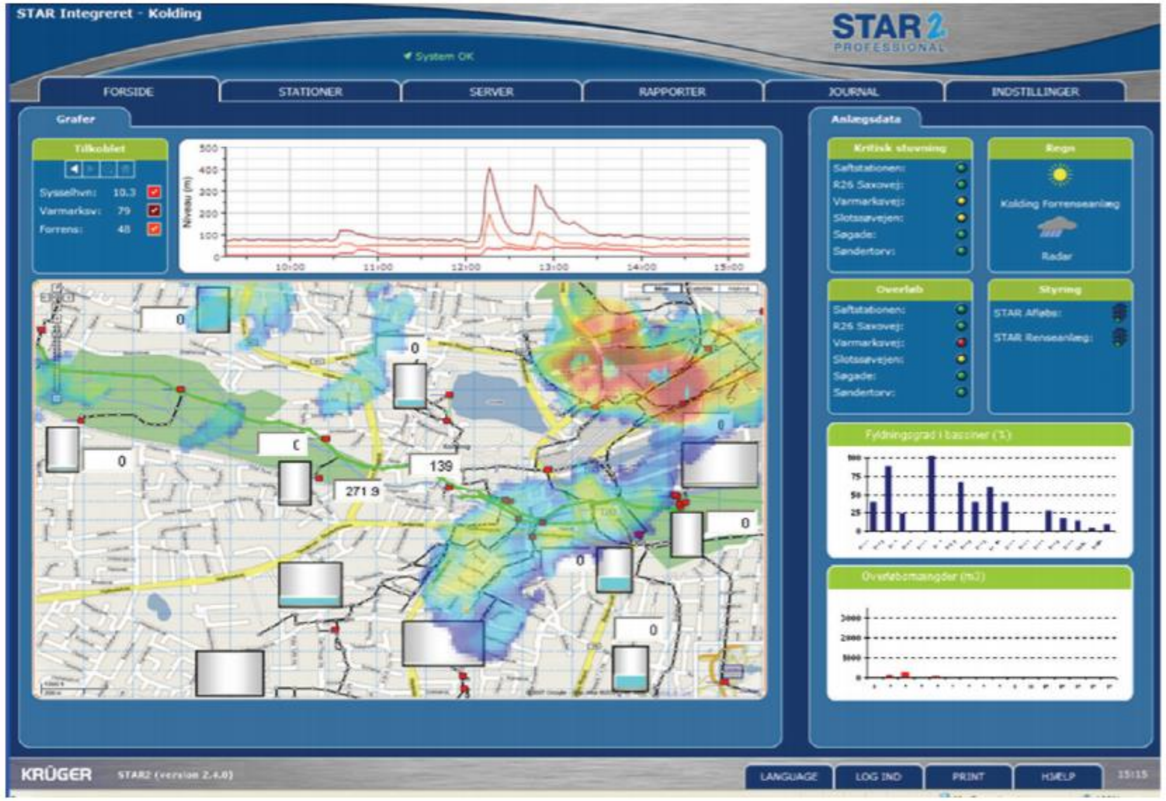


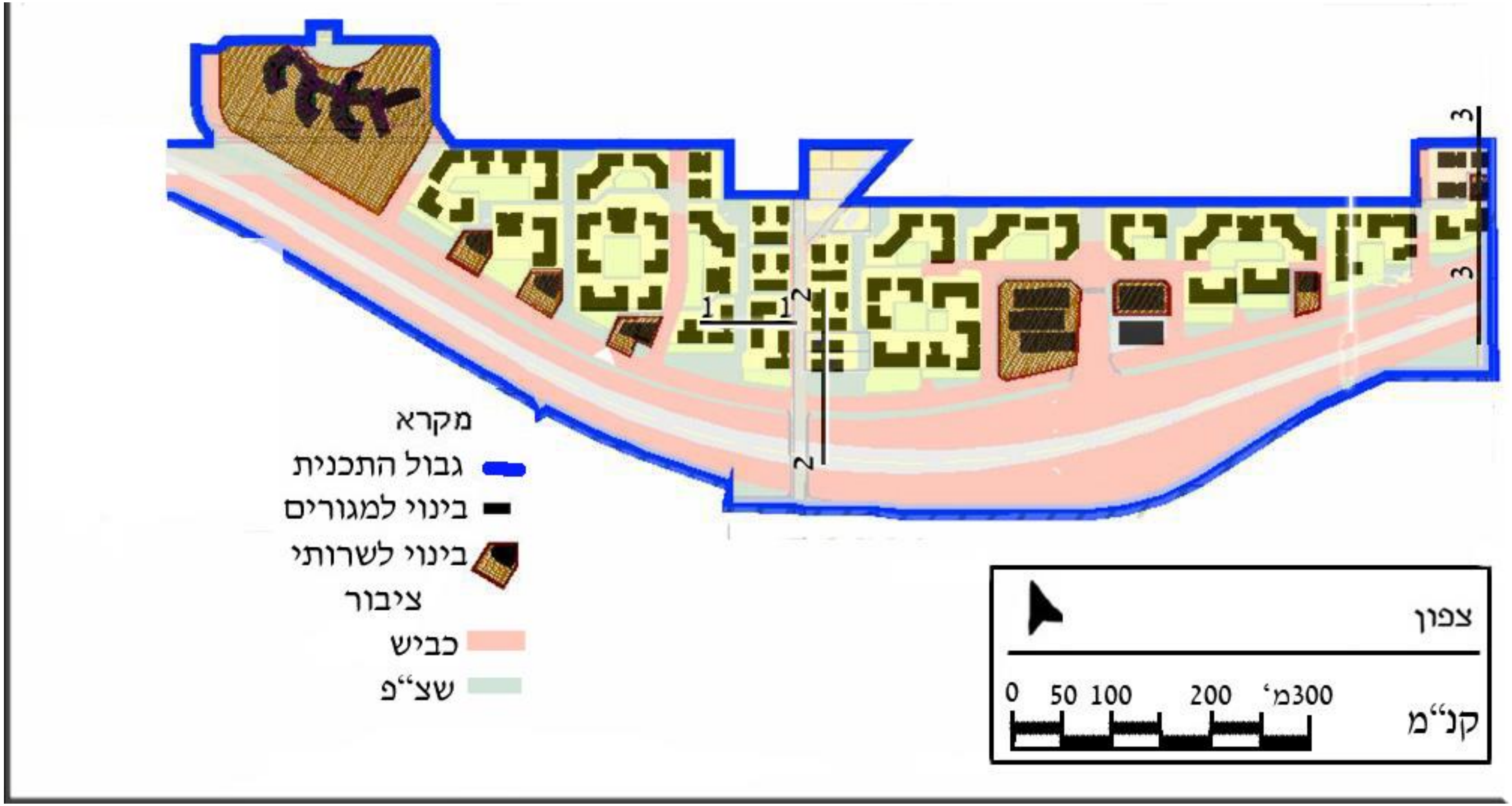
Figure 7: Control platform for integrated control of the sewage system and WWTP with a dynamic overview of the system. The platform is based on STAR2®.

“The performance of the RTC system was evaluated by canculating the reduction in overflow volumes using rain events over the last 10 years. RTC was applied to a full hydrodynamic model setup on 9 pumping stations; furthermore, gates were installed in 7 basins. Control functions were implemented based on total inflow to the wastewater treatment plant, water levels in the basins and in critical parts of the systems. **The study showed a potential for up to 40% reduction in discharge volumes to the Kolding River.**”

http://documents.irevues.inist.fr/handle/2042/32575

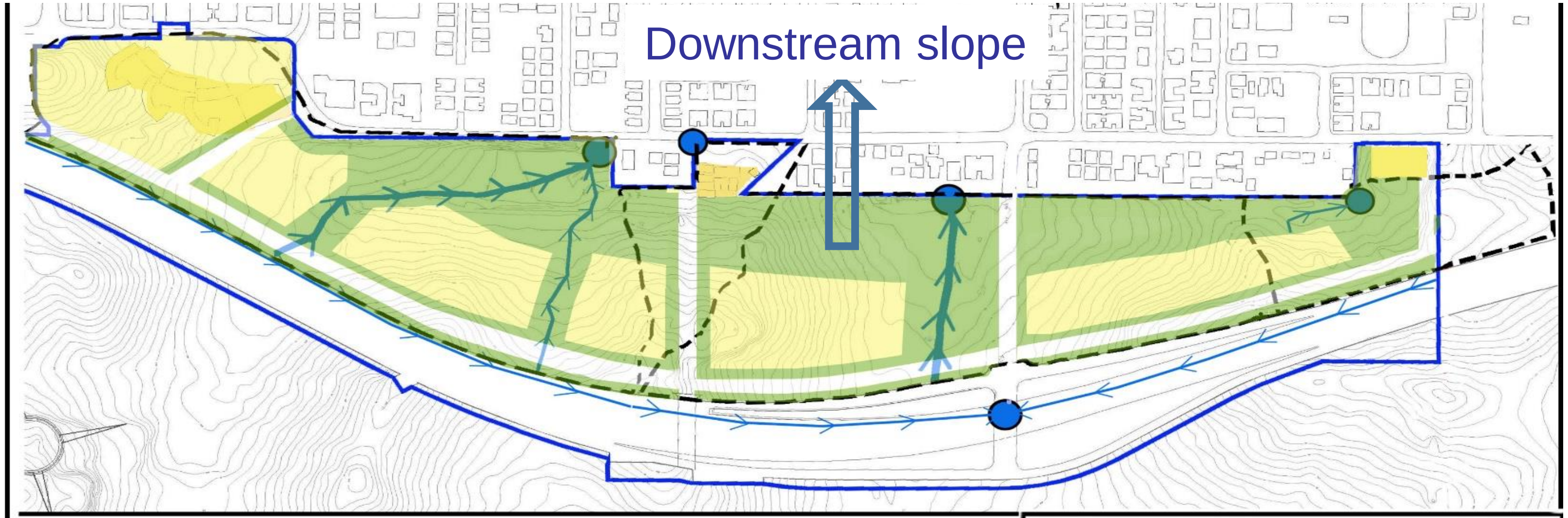
Land use planning

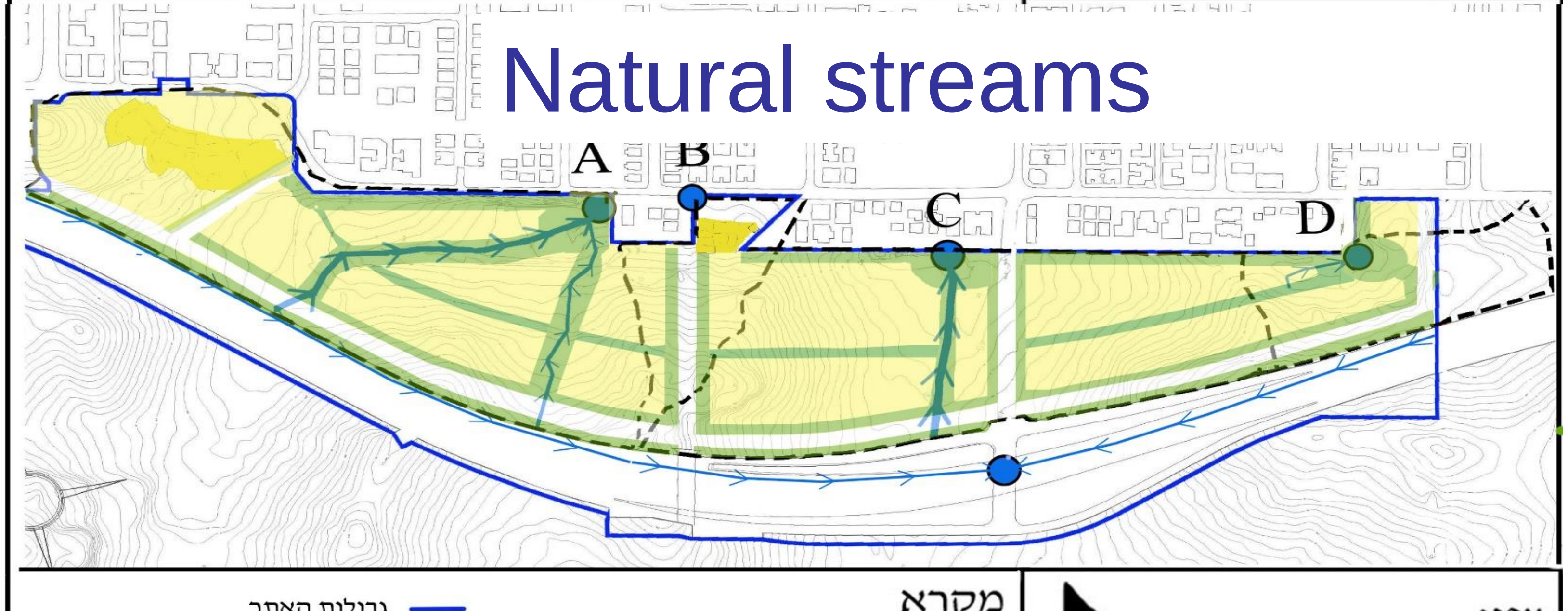
Original plan of the neighborhood (280,000 m^2)



Re-location of buildings & open public spaces

Building upstream – Open spaces downstream





Micro: green and grey BMPs in private and public spaces

Mezzo-Macro: BMPs in public spaces

Nashville, Tennessee, US: ~4,000 m^3 captured annually and used to irrigate the park

M. Surma (2015): green infrastructure study for Wroclaw

- Martyna Surma (2015) Sustainable urban development through an application of green infrastructure in district scale – a case study of Wrocław (Poland). *Journal of Water and Land Development,* 25, p. 3–12
- Three study areas were selected to perform simulation of stormwater management with the possibilities of eco modernization of the grey infrastructure. The districts represent urban structures typical for the whole city.

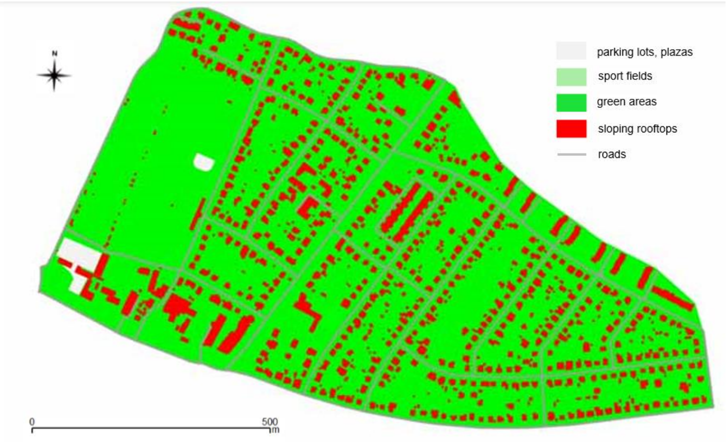


Fig. 2. The types of surfaces; source: own elaboration

Fig. 3. The types of surfaces – multifamily housing district; source: own elaboration

Table 1. Runoff indices according to the Polish norm

Types of surfaces	Runoff index
The roof's slope >15	1.00
The roof's slope <15	0.80
Roof covered with gravel	0.50
Garden on the rooftop	0.30
Impervious surfaces	0.90
Impervious pavements	0.60
Permeable pavements, alleys, backyards	0.50
Playgrounds, sport fields	0.25
Gardens	0.10–0.15
Parks	0.05

Source: own elaboration according to PN-92/B-01707.

Table 3. Drained area (ha) – multifamily housing district – scenario I – now

Types of surfaces	Runoff index x area ha
Rooftops (sloping > 15)	1.80
Rooftops (sloping < 15)	**8.64**
Roads	8.82
Pavements	1.80
Parking lots	2.25
Sport fields	0.35
Green areas	24.6
Total	**48.26**

Source: own elaboration according to PN-92/B-01707.

Table 4. Drained area (ha) – multifamily housing district – scenario II – the alternative option

Types of surfaces	Runoff index x area ha
Rooftops (sloping >15)	1.80
Gardens on the rooftops	**3.24**
Roads	8.82
Pavements	1.80
Parking lots	2.25
Sport fields	0.35
Green areas	24.6
Total	**42.86**

Source: own elaboration according to PN-92/B-01707.

- Total runoff volume = ∑(areas x Runoff Indices)
- Objective = reduce total runoff volume
- Recommendations: use SUDS/LID concepts and methods to change the Runoff Index of planned developed areas, including: green roofs, permeable pavements and backyards, → Permeable ≥ 50% of total area

Built BMPs: Biofilter + Infiltration wells

Winter: bio-filtering of runoff from 3 km^2

Summer: nitrate removal from adjacent wells with 150 mg/l

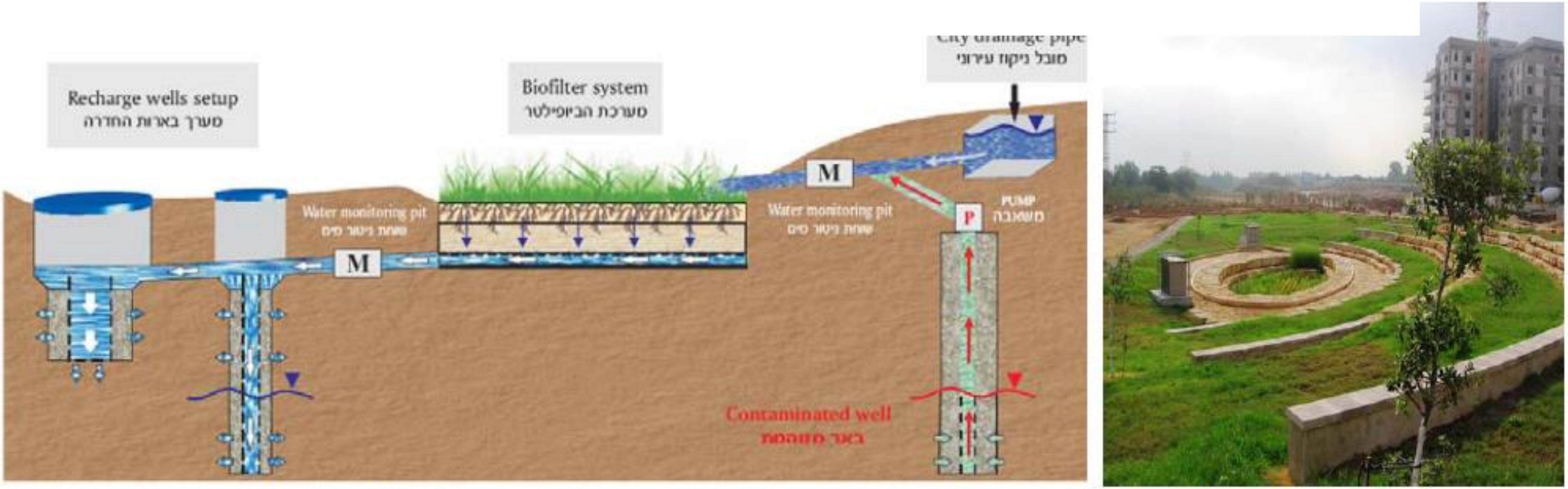


Figure 1. The dual operation stormwater biofilter, Kfar-Sava, Israel.

By: Dr. Yaron Zinger, Monash University and JNF

Built BMPs: underground storage

GRAF

EcoBloc System
Stormwater management

Built BMPs: underground storage

Tokyo: Underground stormwater retention reservoir

Rebirth of the Cheonggyecheon River in Seoul

In 1760 King Yeongjo established regulations for protecting and regulating the Cheonggyecheon River

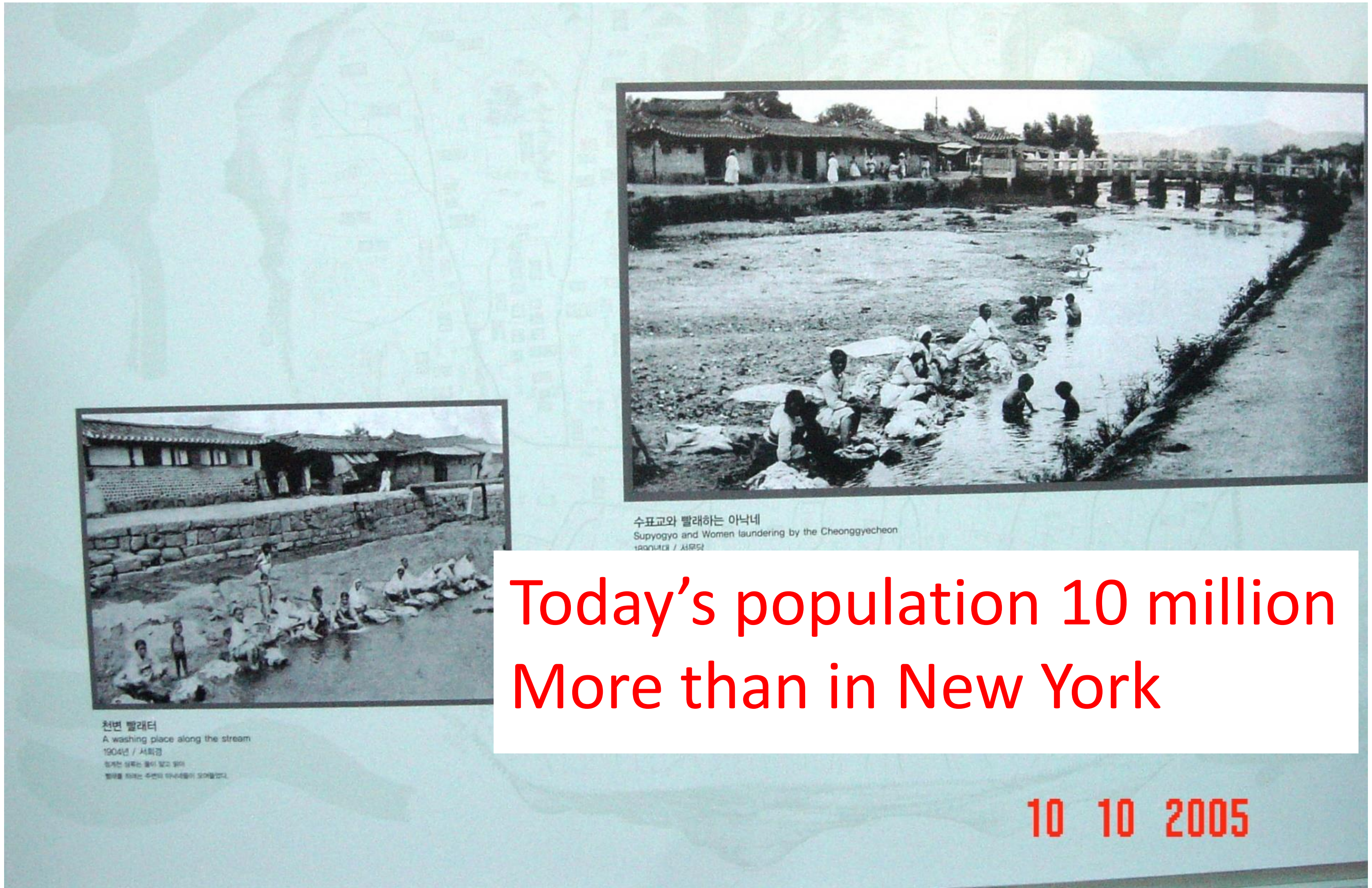
Seoul, South Korea

Rebirth of the Cheonggyecheon River in Seoul

In the early 20th century, immigrants from the countryside settled on the river banks and used it for washing → pollution and very low flows

Rebirth of the Cheonggyecheon River in Seoul

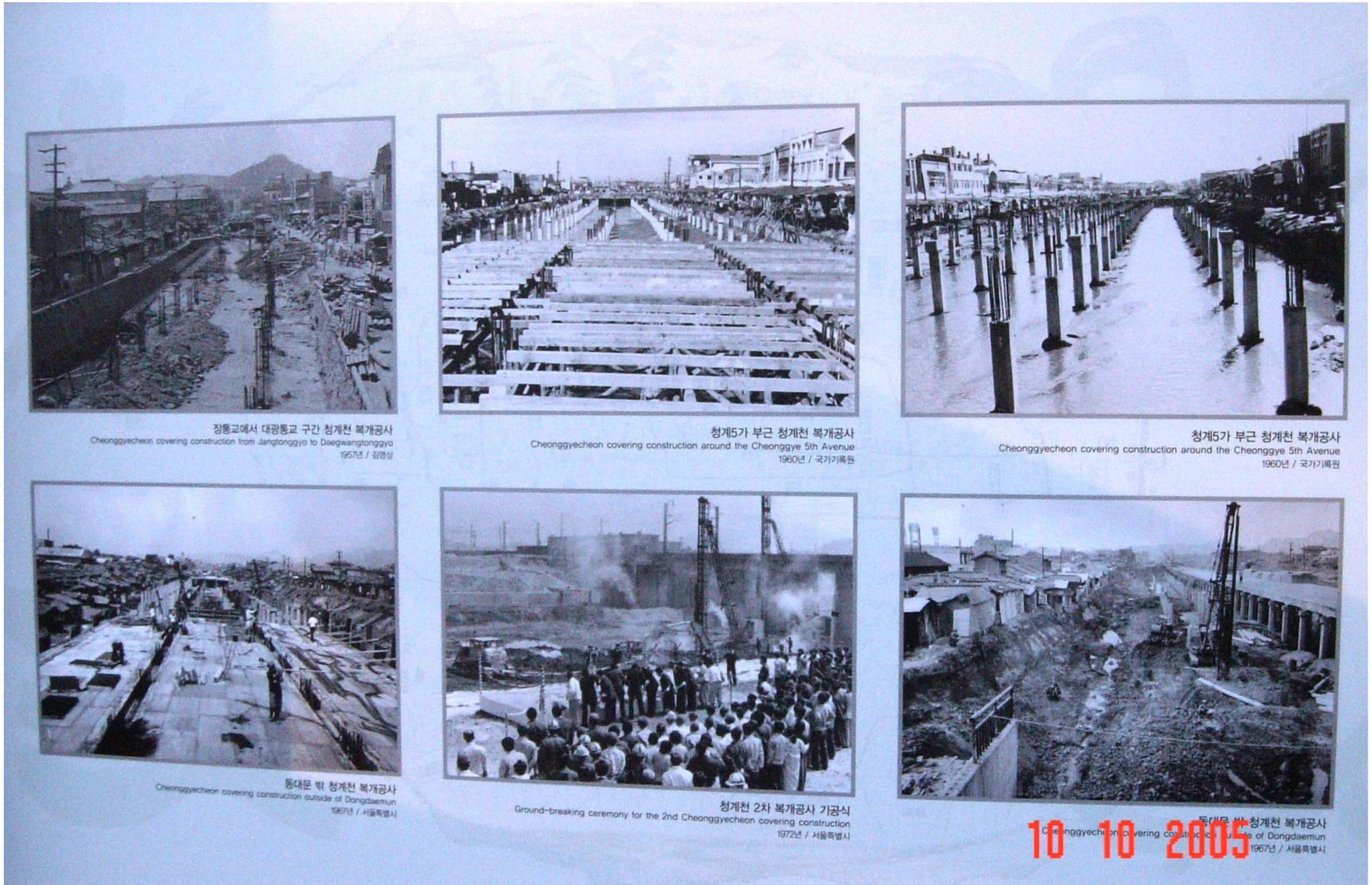
In the early 20th century, immigrants from the countryside settled on the river banks and used it for washing → pollution and very low flows



Today's population 10 million
More than in New York

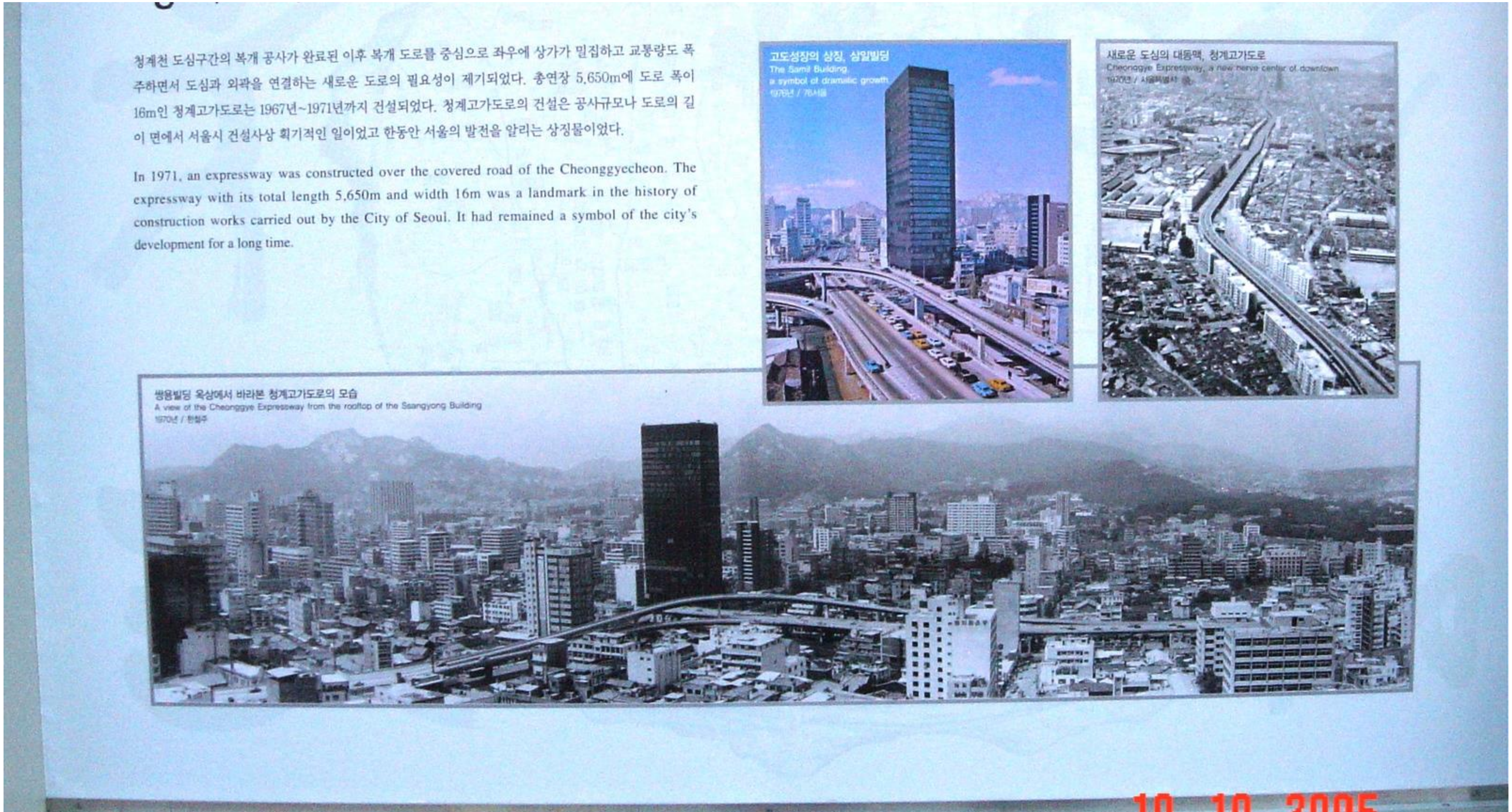
Rebirth of the Cheonggyecheon River in Seoul

In the 1970s this sewage canal was converted into a major highway



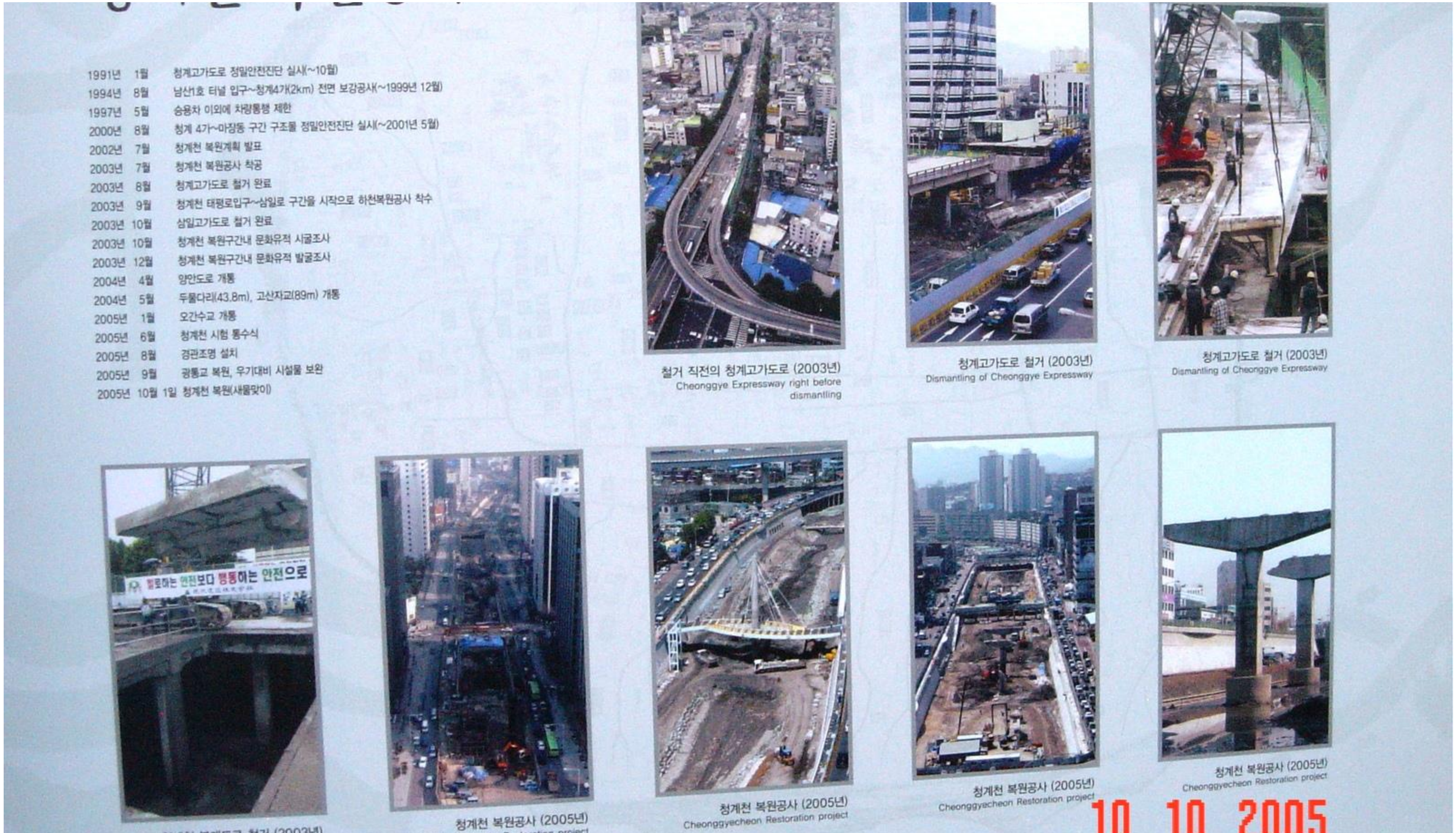
Rebirth of the Cheonggyecheon River in Seoul

A 10 km central two-level highway through the entire city



Rebirth of the Cheonggyecheon River in Seoul

In 2003/2004 the highway was demolished and removed



Rebirth of the Cheonggyecheon River in Seoul

In 2005 the river was re-born, day-lighted

Messages

Messages

- All socially motivated urban water management should be based on solid science
- The Water Hierarchy connects from Science to Society through technology and all levels of governance
- Demand Management is the first and most important component of urban and regional water resources management, using technologies, laws, regulations, education
- Agriculture-To-Urban water transfer is an important water policy

Messages

- Technologies have a central and increasing role to play, combining hardware and software
- Water Sensitive Planning (WSP)encompasses more than stormwater management: it includes use of rainwater and greywater, water supply, wastewater treatment/reuse
- It also connects the city to the regional scale as a common stormwater-shed
- Other approaches have partially different objective but often the same/similar implementation means

The Water Hierarchy: from Science to Society

Thank you