

THE CHALLENGE OF POLLUTION CONTROL OF URBAN RUNOFF

O II Fórum de Engenharia Civil - UTAD
"INOVAÇÃO E SUSTENTABILIDADE NA ENGENHARIA CIVIL"
9 de Maio 2013



Escola de Ciências e Tecnologia da UTAD
Universidade de Tras-os-Montes e Alto Douro



UNIVERSIDADE DA CORUÑA - ESPAÑA



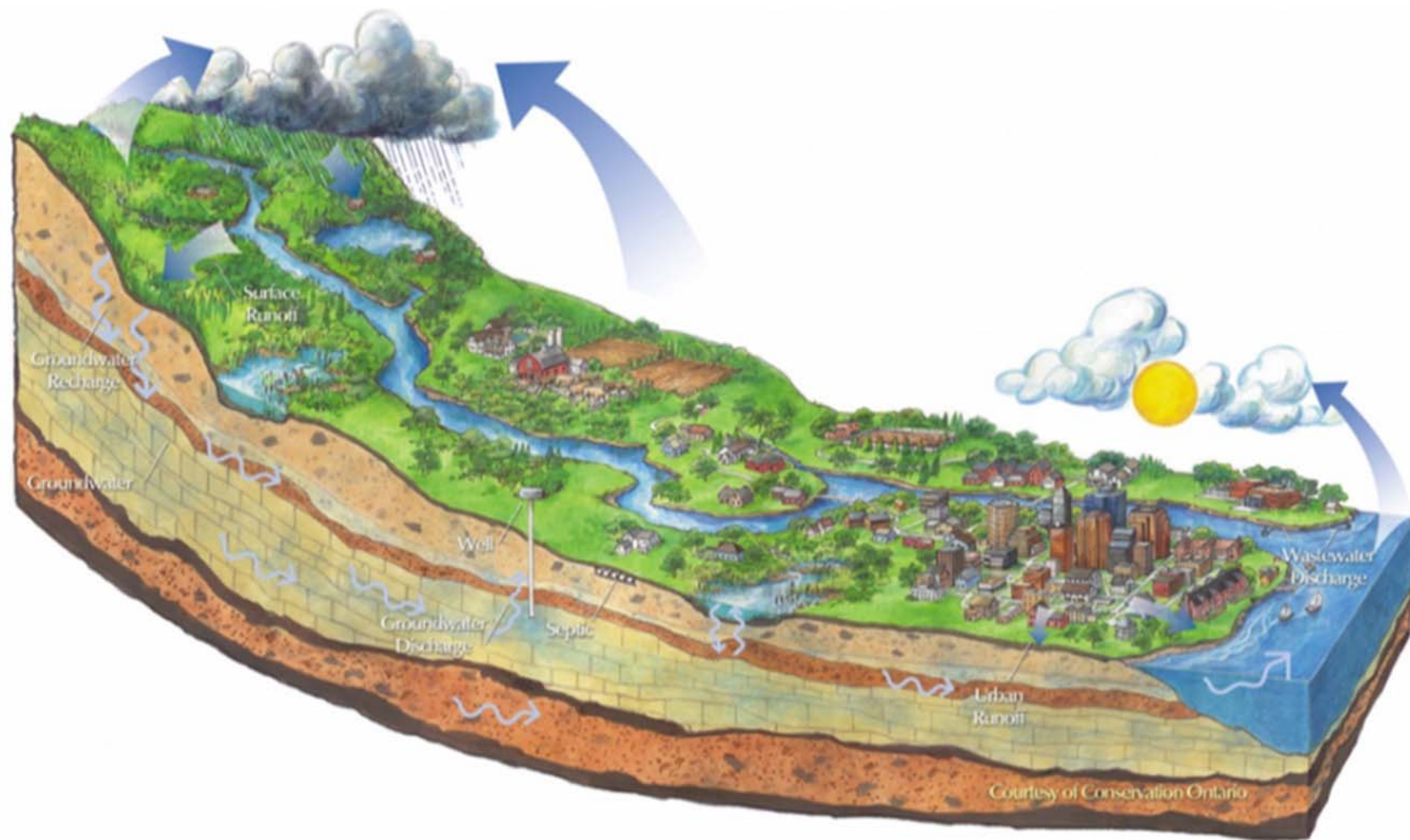
Grupo de Enxeñaría
da Auga e do
Medio Ambiente

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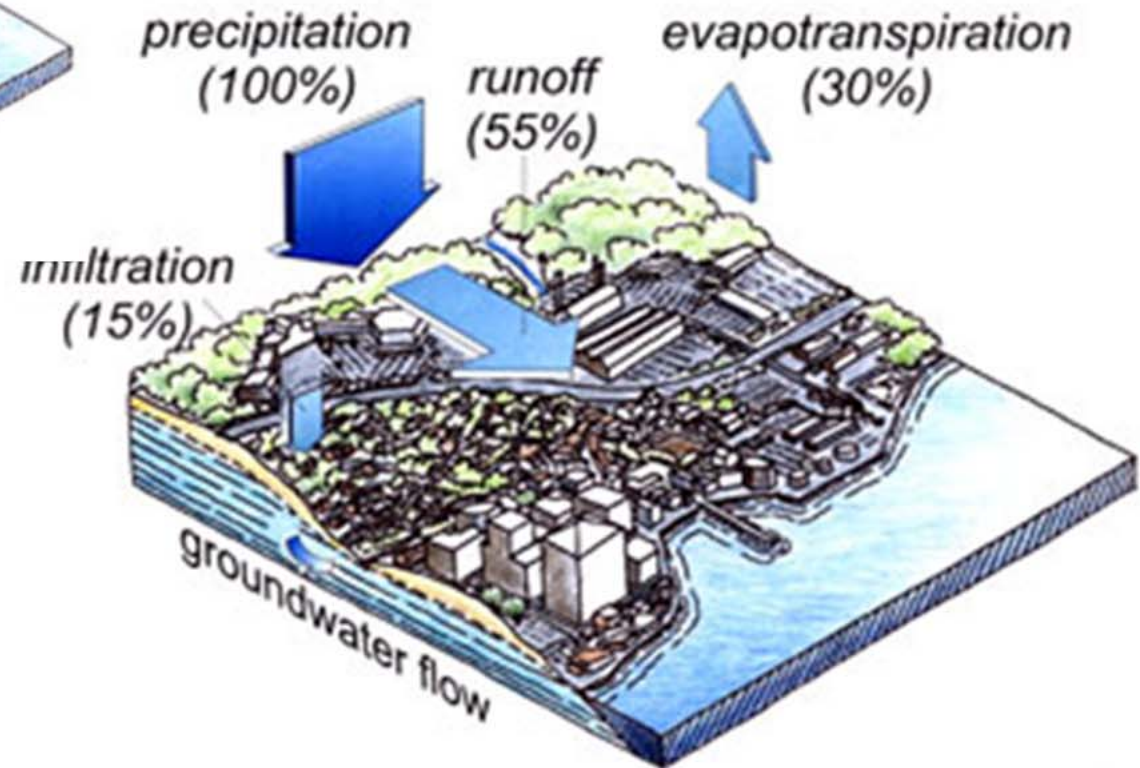
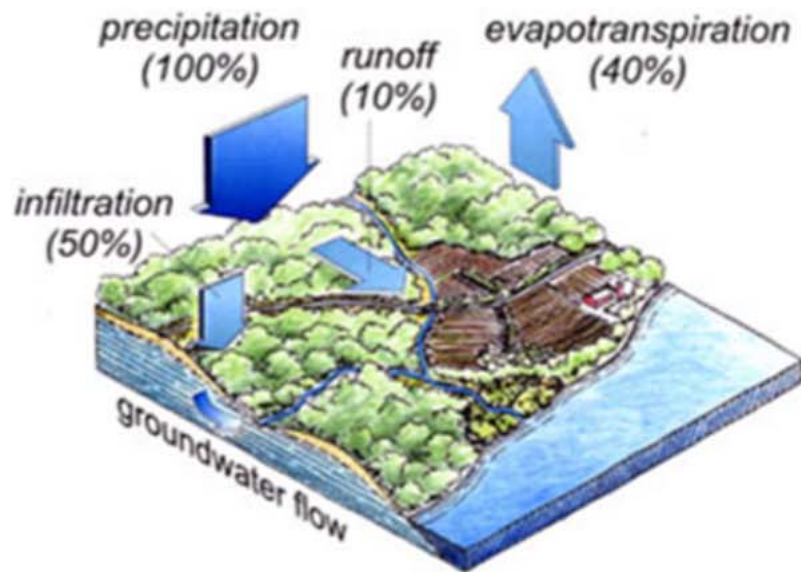
- ❑ **EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE**
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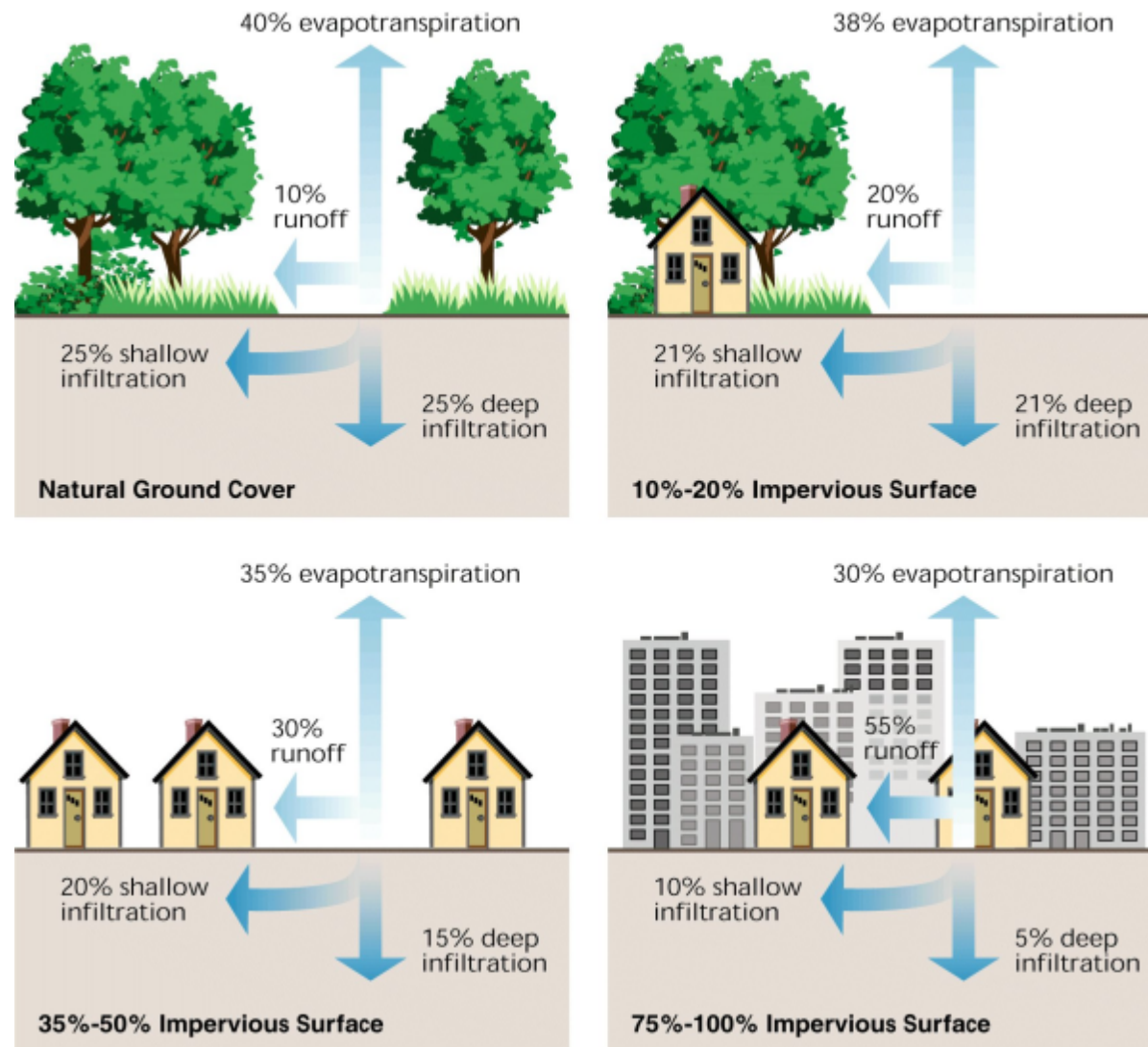
EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE



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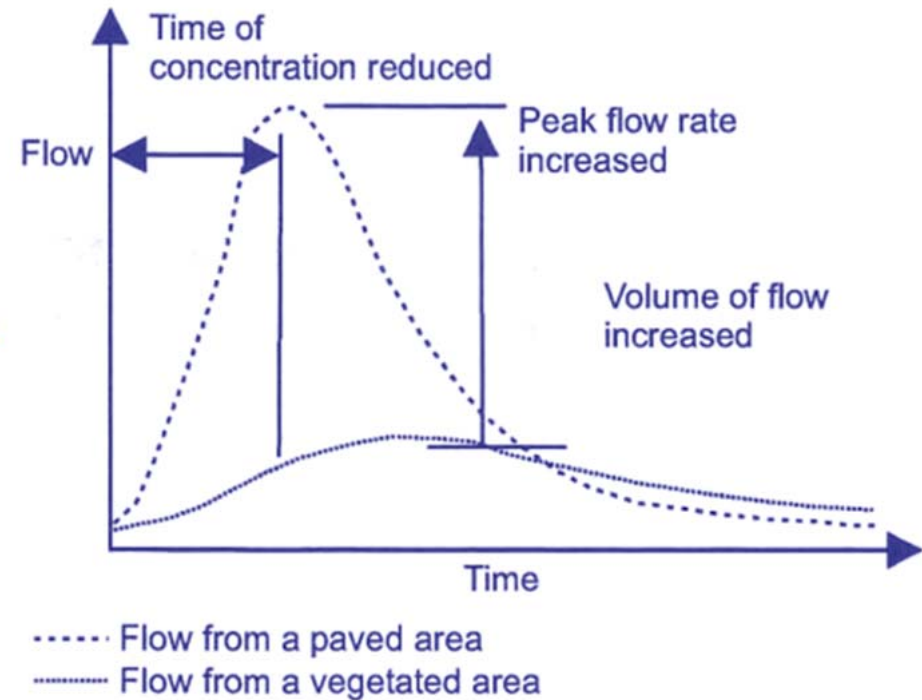
EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE

- In 1800 only 1% of the global population lived in cities of over 10,000 inhabitants.
- In 1960 this proportion was 20%.
- Is expected to be **60% in 2030**.



EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE

- Increased complexity of the design, operation and maintenance of water-related infrastructure.
- Increased soil impermeability produces:
 - ✓ Increased runoff volumes
 - ✓ Increased flow velocities
 - ✓ Reduced concentration time
 - ✓ Higher temperatures in natural channels
 - ✓ Lower base flows during drought
 - ✓ Higher peak flows
 - ✓ **Higher levels of contamination**



EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE



To prevent flooding ...

EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE

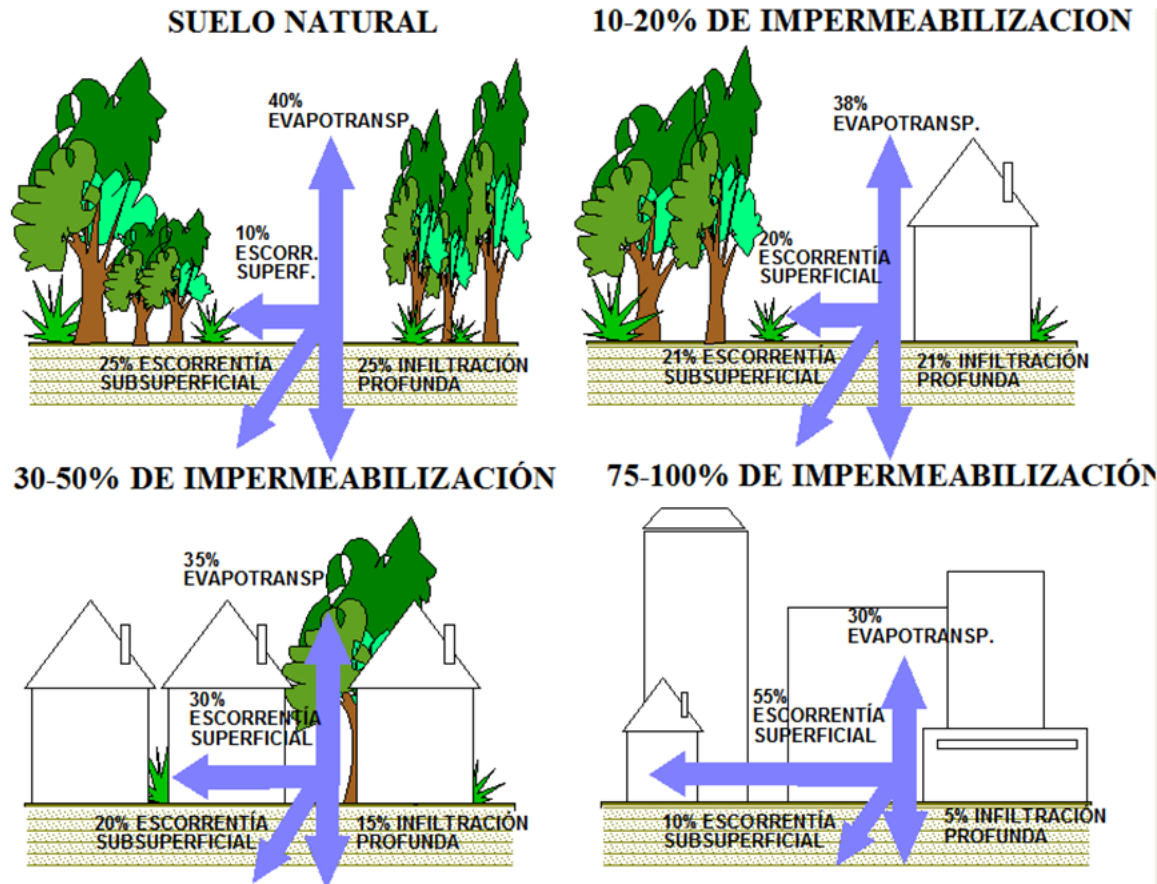


... we design drainage systems that cause damage to aquatic ecosystems.

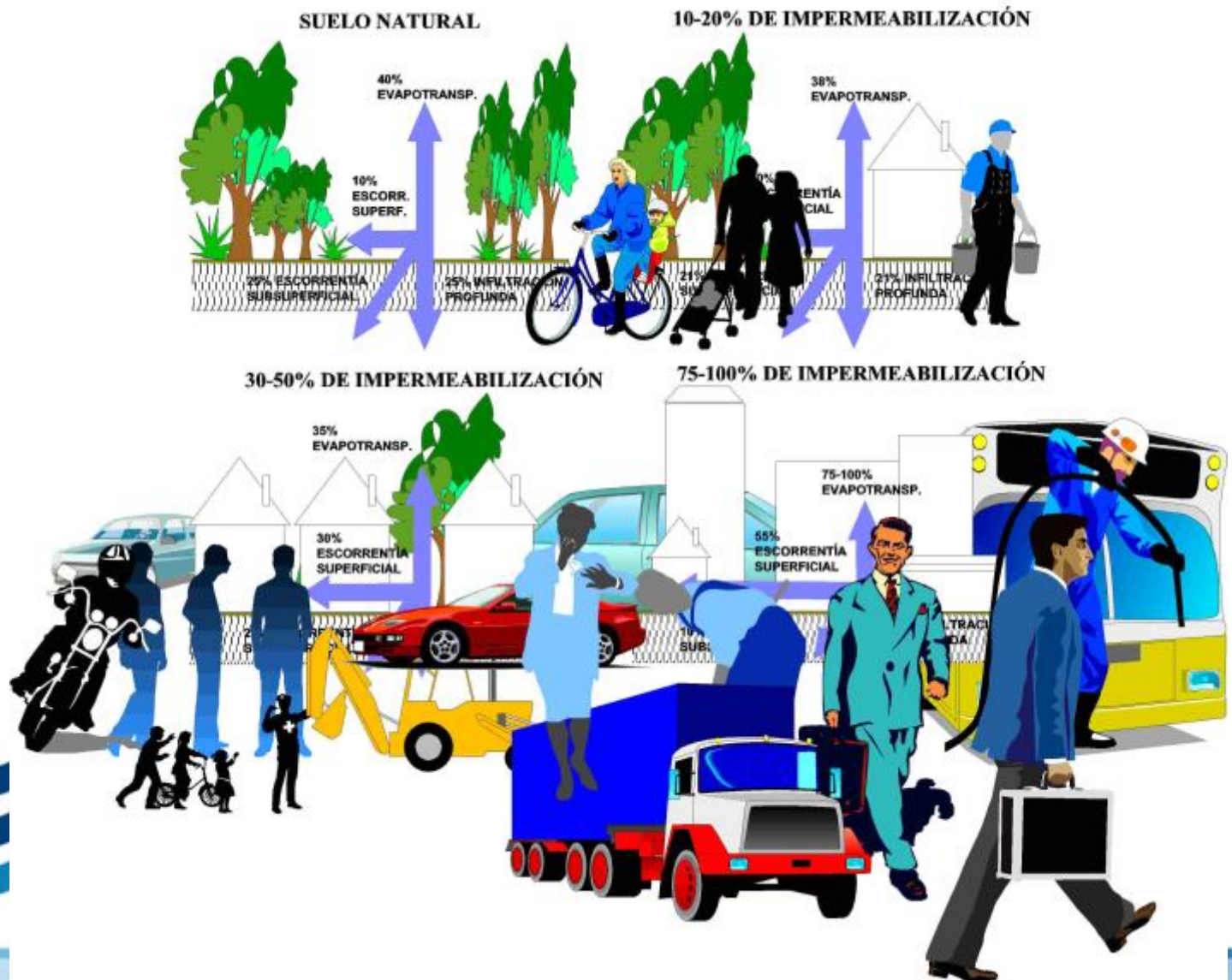
EFFECTS OF URBAN DEVELOPMENT ON THE NATURAL WATER CYCLE



URBAN RUNOFF POLLUTION

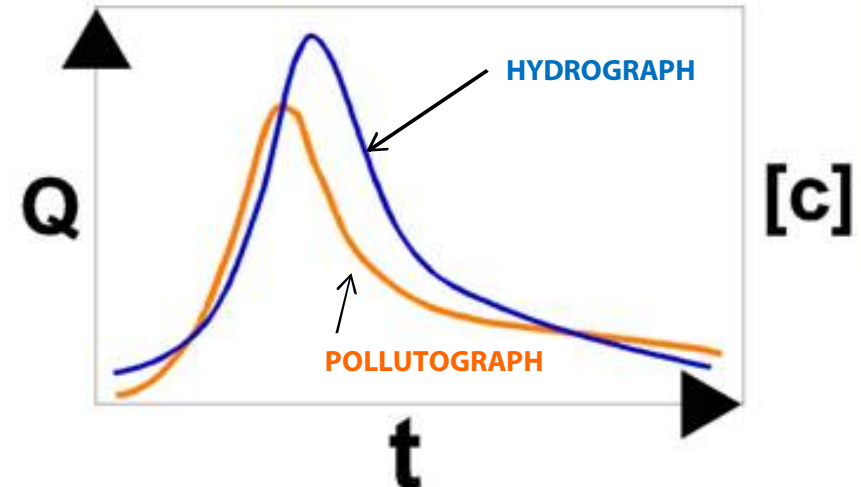
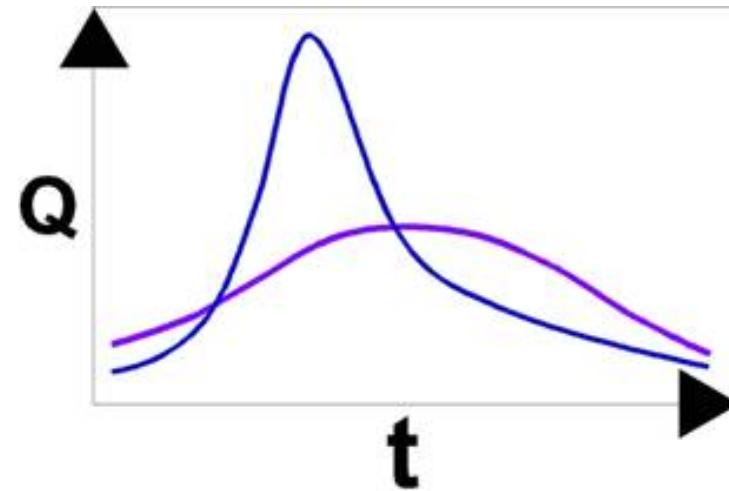


URBAN RUNOFF POLLUTION

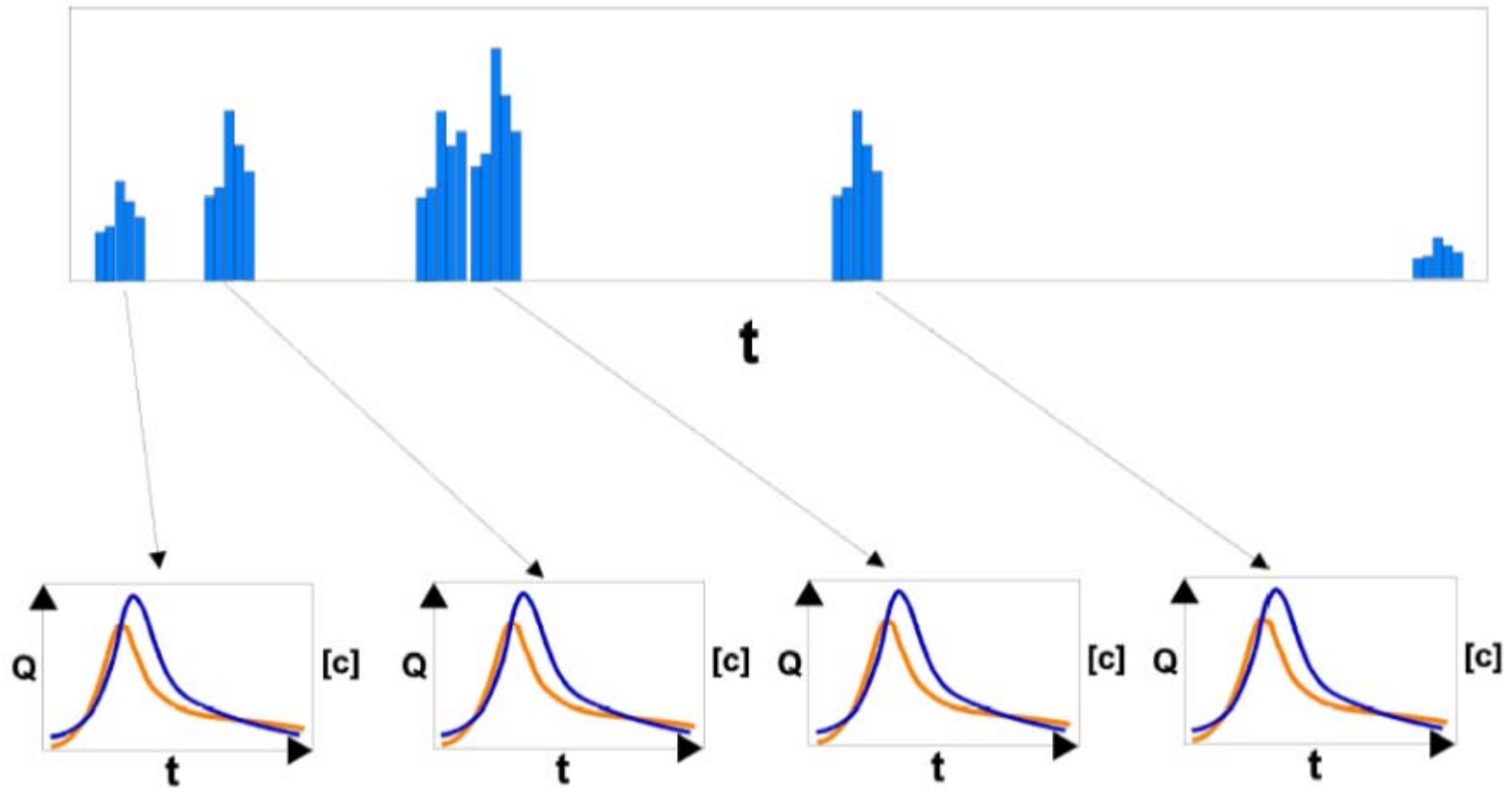


URBAN RUNOFF POLLUTION

- "Federal Water Control Act Amendments" of 1972 and the "Cost Methodolgy of Combined Sewer Overflows and Storm Discharges".
- NURP ("Nationwide Urban Runoff Program") (1978 - 1983),
- "Final Report of the Nationwide Urban Runoff Program"



URBAN RUNOFF POLLUTION



URBAN RUNOFF POLLUTION / case study 1 - experiences



ROAD DRAINAGE IN FENE- GALICIA (SPAIN)

The catchment runoff is directly spilled to the Ferrol estuary, which is considered as a sensitive aquatic media following the European urban wastewater treatment Directive 91/271/EEC criteria.



URBAN RUNOFF POLLUTION / case study 1 - experiences



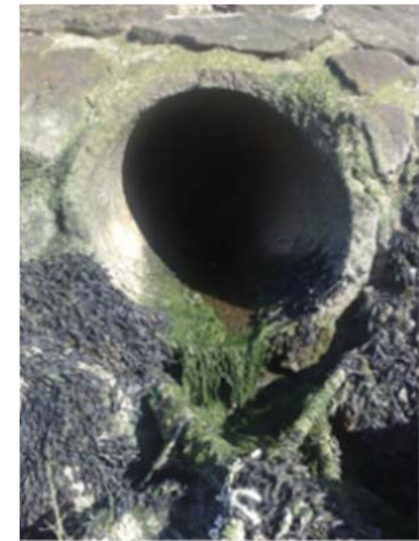
URBAN RUNOFF POLLUTION / case study 1 - experiences



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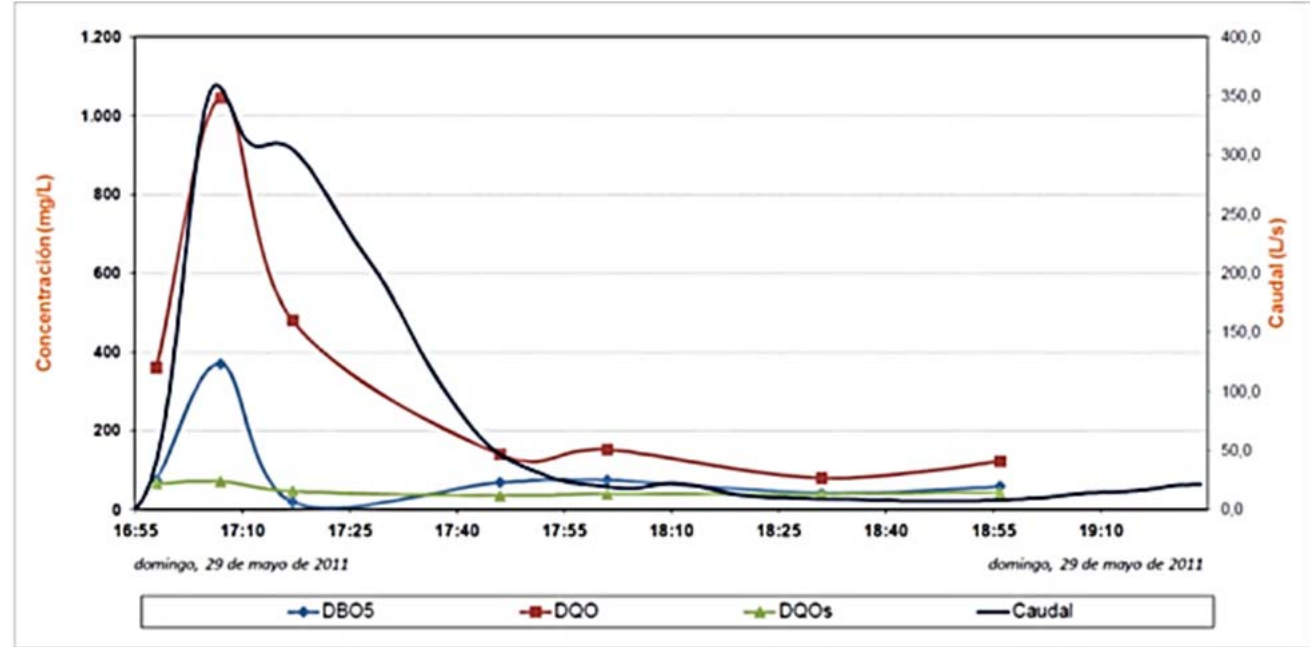
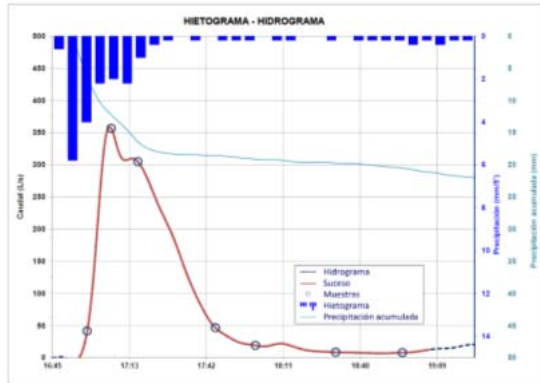
SUCESO 3 / FENE-SAN VALENTÍN

8-7-2010

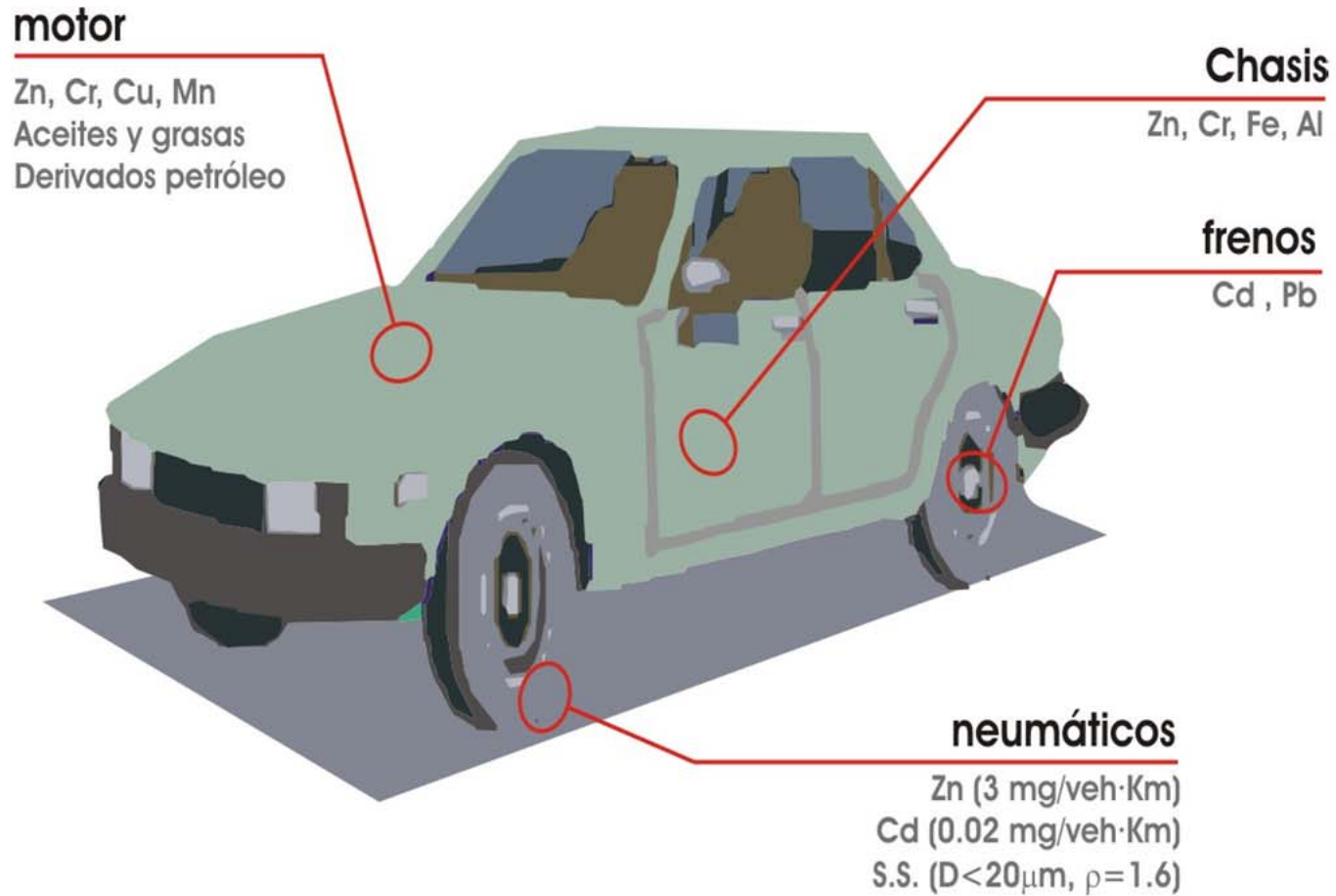
6 DÍAS DE TSP / 19:15 horas

	M1	M2	M3
DQO	738 mg/L	283 mg/L	29,1 mg/L
DQO disuelta	80,4 mg/L	31,8 mg/L	24,1 mg/L
DBO5	36 mg/L	22 mg/L	9 mg/L
SS	1392 mg/L	354 mg/L	55 mg/L
EC	1×10^4 UFC/100 mL	2×10^3 UFC/100 mL	$1,5 \times 10^3$ UFC/100 mL

URBAN RUNOFF POLLUTION / case study 1 - experiences



URBAN RUNOFF POLLUTION / case study 1 - experiences



URBAN RUNOFF POLLUTION / case study 1 - experiences

RESULTS AFTER 12 EVENTS OF RAIN CHARACTERIZED

	Orden de magnitud de concentraciones Stockholm Vatten (2001)		Harrison (1991)	Storhaug, R. (1996) Noruega	FENE – AVDA. AS PÍAS		
	Bajas	Altas	Autopista		Media de las C _{max}	CMS	VALORACIÓN
DQO	25 -60				206	127,1	ALTA
SST (mg/L)	< 50	> 175			450	185,7	ALTA
N _{tot} (mg/L)	< 1,25	> 5,0			4,18	2,9	MEDIA
P _{tot} (mg/L)	< 0,1	> 0,2			0,63	0,43	ALTA
Pb (µg/L)	< 3,0	> 15,0	100	1 - 33	14,252	9,033	MEDIA
Cd (µg/L)	< 0,3	> 1,5	2	0,1 - 0,5	0,336	0,087	BAJA
Hg (µg/L)	< 0,04	> 0,20		0,2 – 1,2	0,134	0,049	BAJA
Cu (µg/L)	< 9,0	> 45,0	60	6 -120	51,285	37,07	MEDIA-ALTA
Zn (µg/L)	< 60,0	> 300	100	10 - 300	213,049	119,36	MEDIA
Ni (µg/L)	< 45,0	> 225		3 - 190	8,025	4,627	BAJA
Cr (µg/L)	< 15,0	> 75		1 - 170	7,877	4,580	BAJA
Aceites (mg/L)	< 0,5	> 1,0			8,330	4,845	ALTA
HAP (µg/L)	< 1,0	> 2,0		0,1 – 2,7	9,540	2,582	ALTA
Fluoranteno (µg/L)			0,1		2,029	0,524	
Benzo(a)pireno (µg/L)			0,3		0,704	0,125	

MEDIA AND HIGH POLLUTION VALUES MEASURED

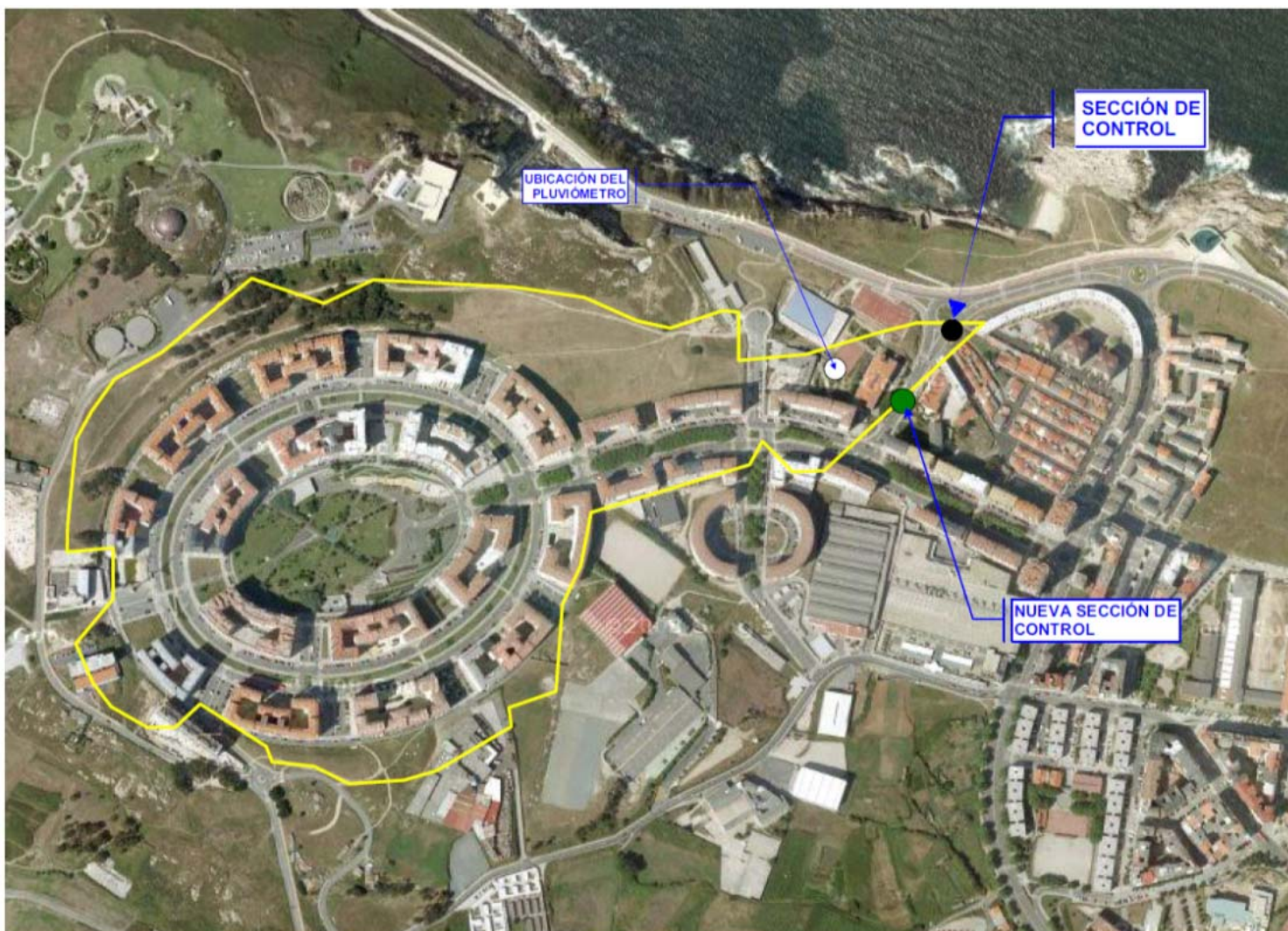
CLEAR NEED FOR TREATMENT

URBAN RUNOFF POLLUTION / case study 2 - experiences



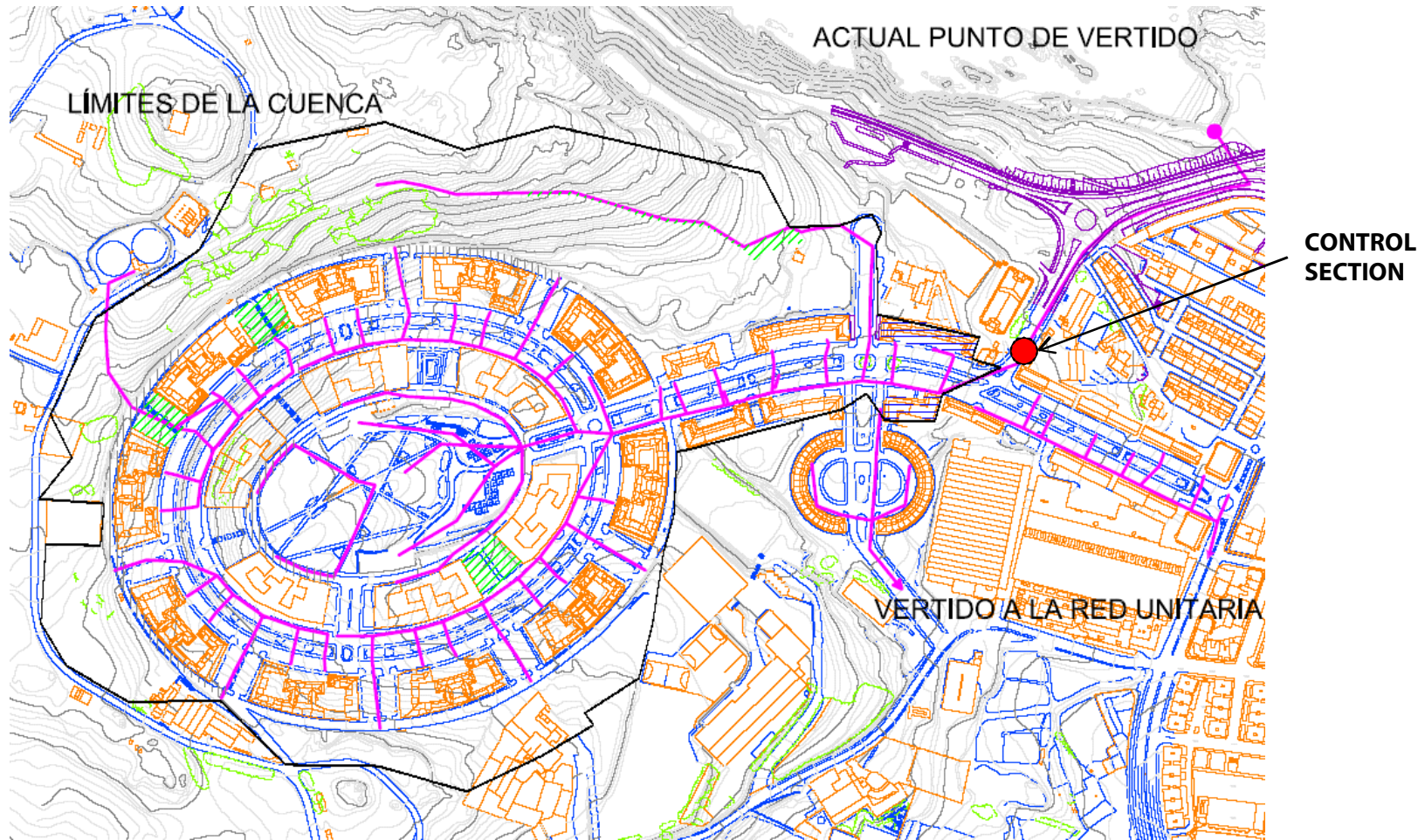
**SEPARATIVE SUB-CATCHMENT OF
“LOS ROSALES” - A CORUÑA (SPAIN)**

URBAN RUNOFF POLLUTION / case study 2 - experiences



URBAN RUNOFF POLLUTION / case study 2 - experiences

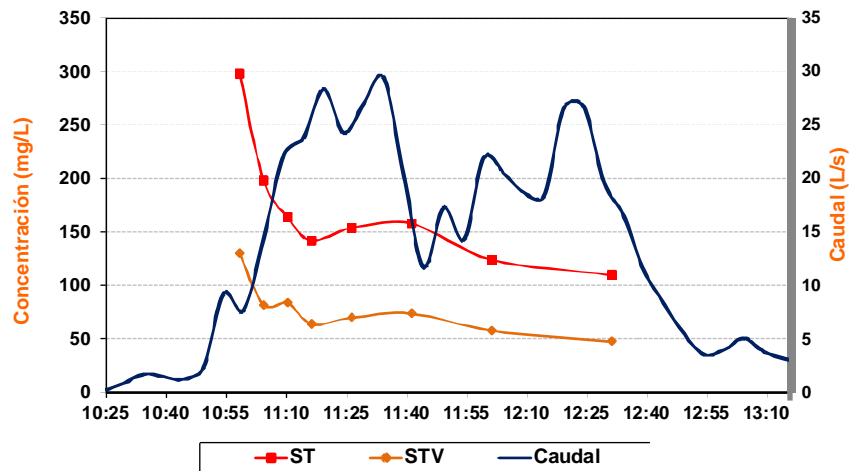
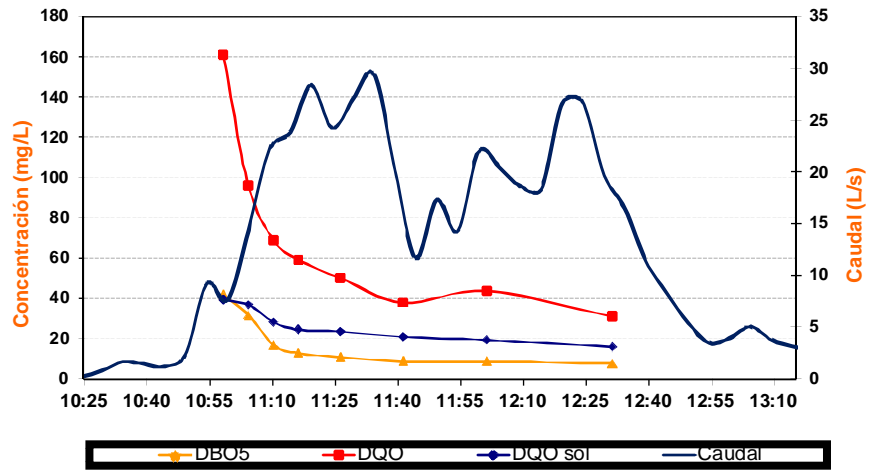
SEPARATIVE SUB-CATCHMENT OF "LOS ROSALES" - A CORUÑA (SPAIN)



URBAN RUNOFF POLLUTION / case study 2 - experiences



URBAN RUNOFF POLLUTION / case study 2 - experiences



URBAN RUNOFF POLLUTION / case study 2 - experiences

RESULTS AFTER 10 EVENTS OF RAIN CHARACTERIZED

PARÁMETROS DE CONTAMINACIÓN	CMS (mg/L) (ELLIS, 1986)	CMS (mg/L) (US-EPA, 1999)	STOCKOLM VATTEN (2001)		“LOS ROSALES”
			Bajas	Altas	
Sólidos en suspensión (mg/L)	21 -2582 (190)	20 – 2890 (150)	<50	>175	43.8
DBO ₅ (mg/L)	7 – 22 (11)				11.6
DQO (mg/L)	20 – 365 (85)	200 – 275 (75)	25	60	42.6
Nitrógeno amoniacal (mg/L)	0.2 -4.6 (1.45)				0.2
N total (mg/L)	0.4 -20.0 (3.2)	0.4 - 20.0 (2)	<1.25	>5	2.2
P total (mg/L)	0.02 – 4.30 (0.34)	0.02 - 4.30 (0.36)	<0.1	>0.2	0.3
Pb total (mg/L)	0.01- 3.1 (0.21)	0.01 - 1.2 (0.18)	<0.003	>0.015	0.007
Zn total (mg/L)	0.01 – 3.68 (0.30)	0.01 - 2.9 (0.2)	<0.060	>0.300	0.077
Cu total (mg/L)		0.01 - 0.40 (0.05)	<0.009	>0.045	0.035
CF (NMP/100 mL)	400 – 50000 (6*10 ³)	400 – 5*10 ⁴			3,4*10⁴

LOW POLLUTION VALUES MEASURED

IT IS AN OPORTUNITY FOR USE IN THE SUBCATCMENT



IT WAS NECESSARY A NEW APPROACH TO URBAN DRAINAGE ENGINEERING.

WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF

Common Implementation Strategy for the Water Framework Directive (2000/60/EC)



Guidance document n.º 3

Analysis of Pressures and Impacts

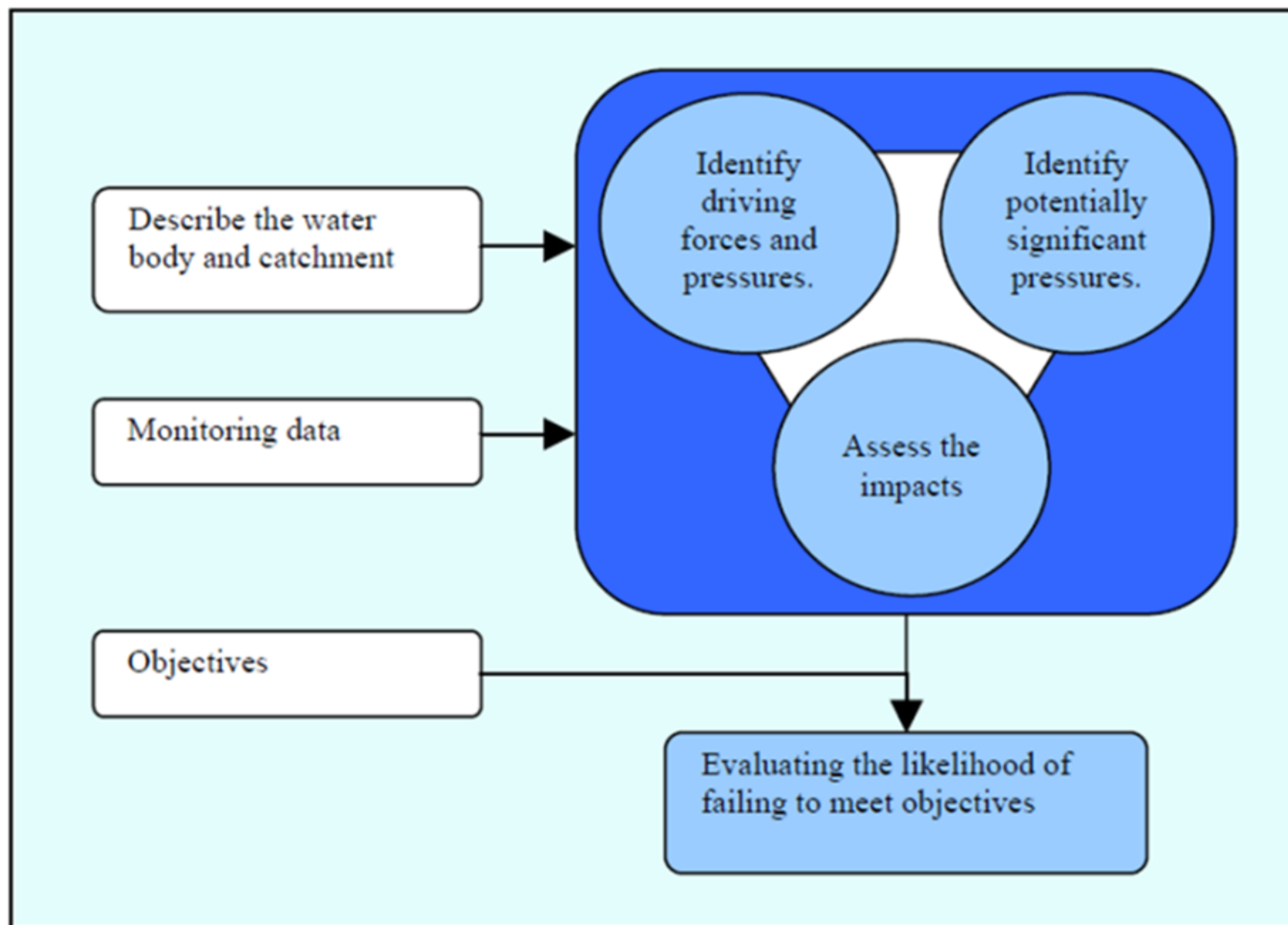


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WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF



WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF

IDENTIFYING DRIVING FORCES AND PRESSURES

- Key components in the analysis of pressures and impacts.
- The guide List of driving forces and pressures which can be used as a checklist to form an inventory of the relevant pressures.
- In addition to a general description of the water body, it is essential to identify the driving forces that may be exerting pressures on the water body.



WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF

Table 4.2 Uncompleted list of Pressures to be considered

n°	SOURCE	Source within the source type
10	DIFFUSE SOURCE	
12	urban drainage (including runoff)	industrial/commercial estates
11		urban areas (including sewer networks)
16		airports
19		trunk roads
19		railway tracks and facilities
19		harbours
13		crops with intensive nutrient or pesticide usage or long bare soil periods (e.g. corn, potato, sugar beets, vine, hops, fruits, vegetables)
13		over grazing - leading to erosion
13		horticulture, including greenhouses
13		application of agricultural waste to land
15	forestry	peat mining
15		planting/ground preparation
15		felling
15		pesticide applications
15		fertilizer applications

WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF

*Guidance Document No. 3
Analysis of Pressures and Impacts*

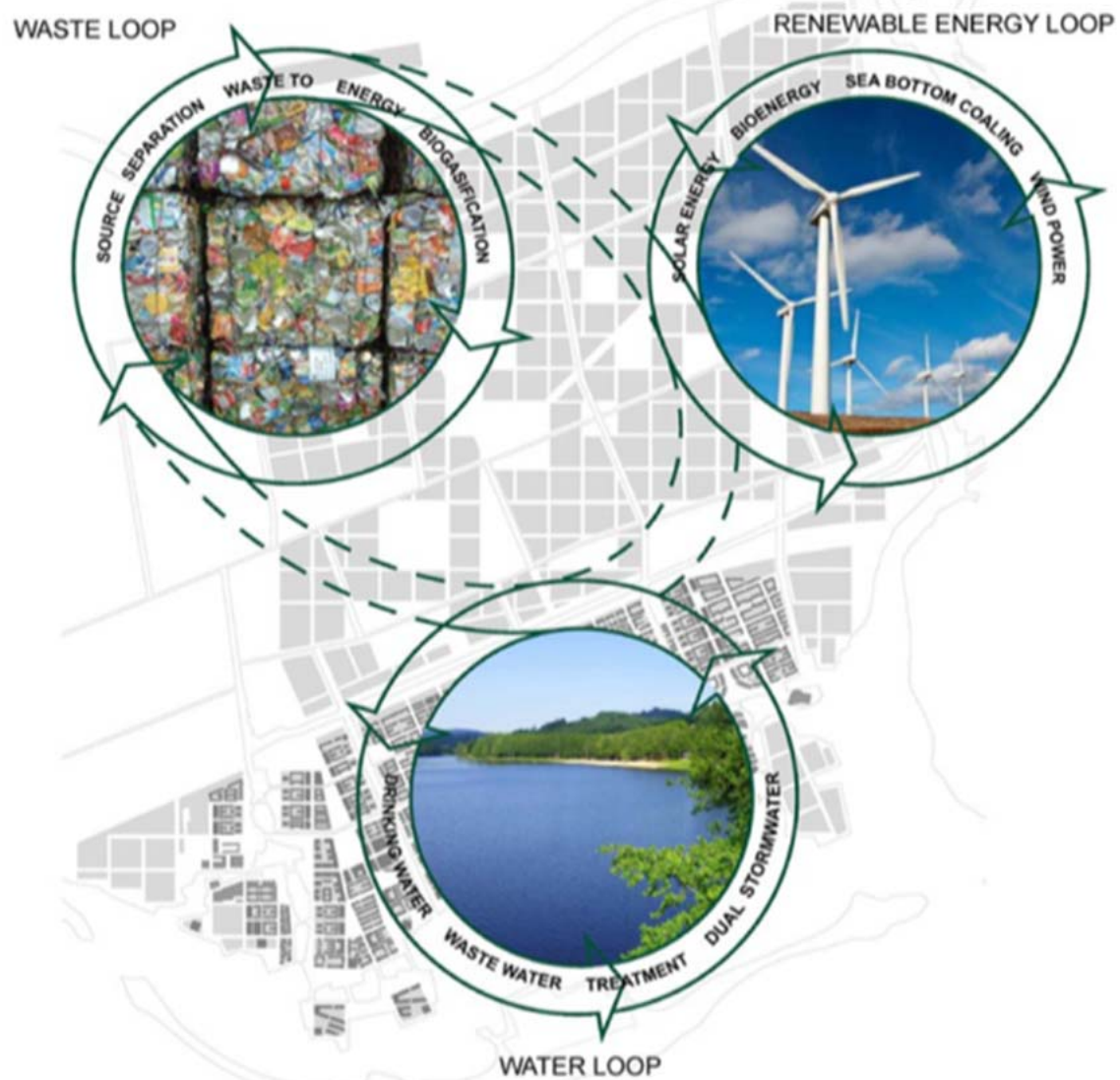
n°	SOURCE	Source within the source type
22		drainage
19		oil pollution
19		atmospheric deposition
19		dredge spoil disposal into surface waters
19		shipping/navigation
POINT SOURCE		
11	waste water	municipal waste water primarily domestic
11		municipal waste water with a major industrial component
11		storm water and emergency overflows
11		private waste water primarily domestic
11		private waste water with a major industrial component
19		harbours
12		chemicals (organic and inorganic)
12		pulp, paper & boards
12		woollens/textiles
12		iron and steel
12		food processing
12		brewing/distilling
12		electronics and other chlorinated solvent users

WATER FRAMEWORK DIRECTIVE (2000/60/CE) and URBAN RUNOFF

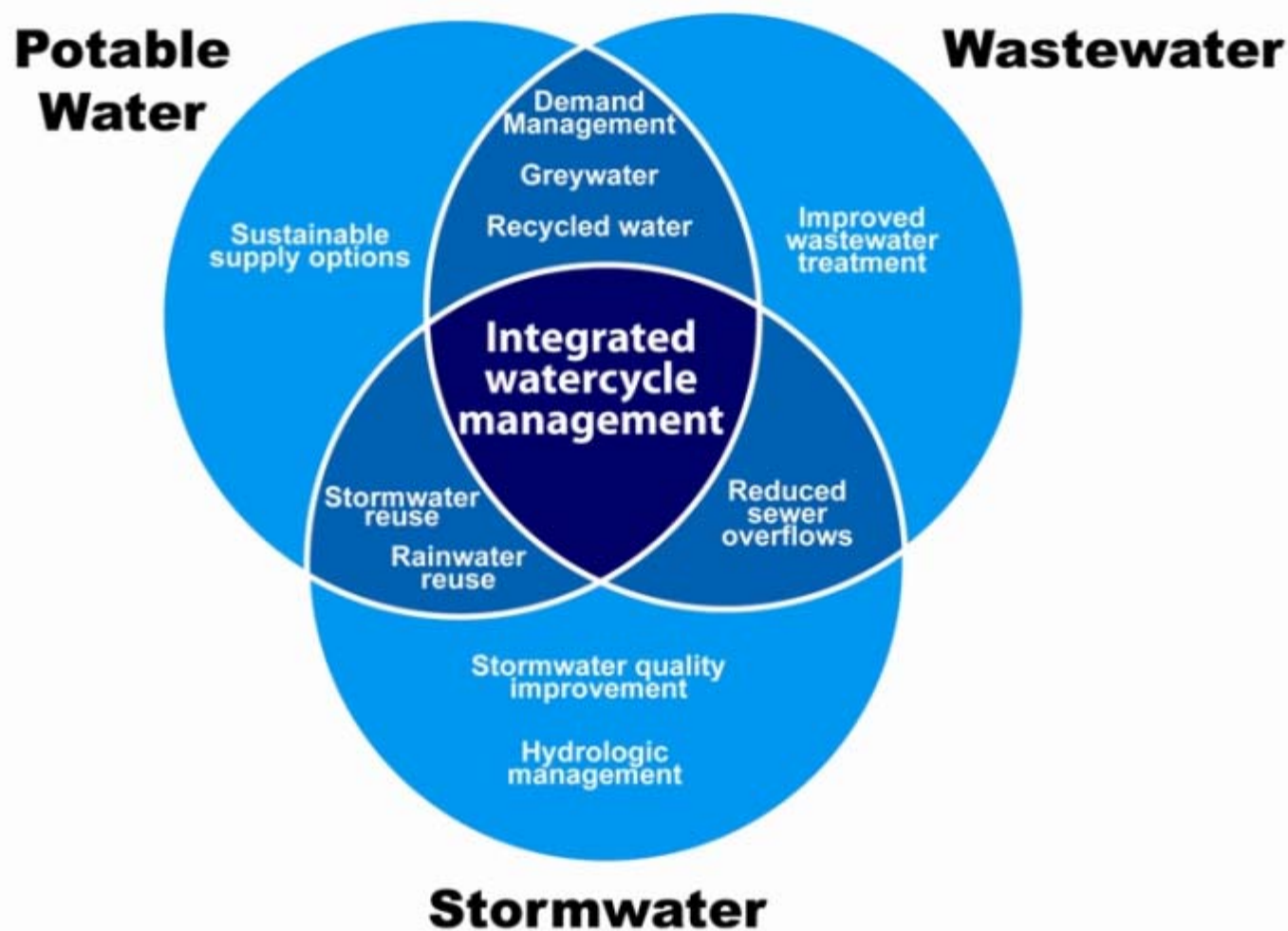
Table 3.2 Examples of diffuse source pressures and their impacts.

Activity or Driving force	Pathway causing Pressure	Possible change in state or impact
Agriculture	Nutrient loss from agriculture by <ul style="list-style-type: none"> • surface runoff • soil erosion • artificial drainage flow • leaching (<i>i.e.</i> interflow, spring water and groundwater) (includes excess fertilisers and manures and mineralization of residues)	Nutrients modify ecosystem
	Pesticide loss by pathways mentioned above	Toxicity, contamination of potable water supplies
	Sediment loss by soil, bank and riverbed erosion	Smothering of bed, alteration of invertebrate assemblage, loss of spawning grounds
Industry discharges to the atmosphere	Deposition of compounds of sulphur and nitrogen	Acidification of surface and groundwater bodies
Transportation	Pollutant spillages	Gross pollution of water bodies
	Use of salt as de-icer	Elevated chloride concentration
	Use of herbicides	
	Engine exhausts	Increase in acidifying chemicals in atmosphere and hence deposition

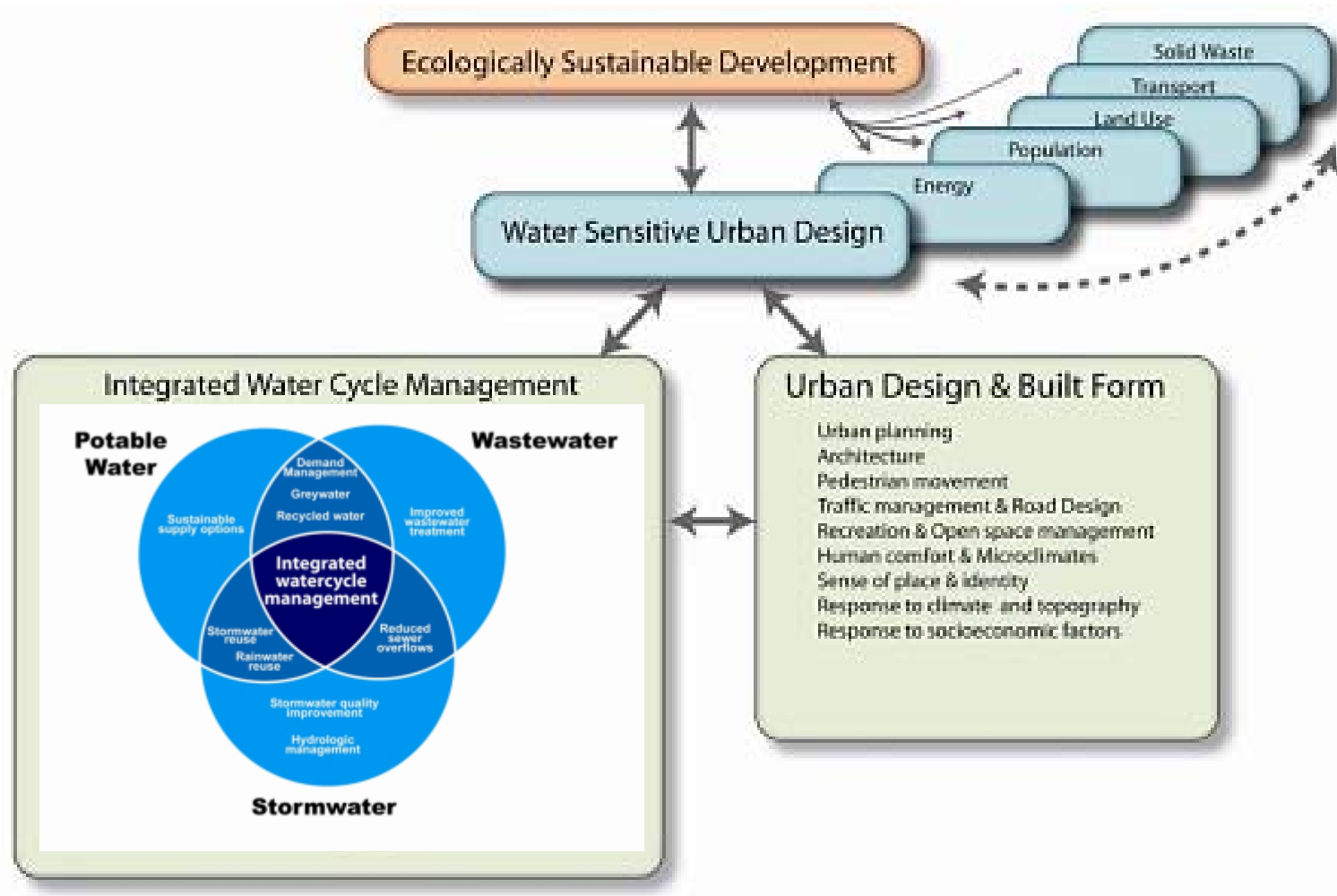
INTEGRATED WATERCYCLE MANAGEMENT



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INTEGRATED WATERCYCLE MANAGEMENT

STRATEGIES AND TOOLS FOR INTEGRATED URBAN WATER CYCLE MANAGEMENT

STRATEGIES:

- “Water Sensitive Urban Desing”, WSUD
- “Low Impact Development”, LID
- “Planning for SuDS”
- “Hydrologic urban rehabilitation”

Tools:

- **SUDS** – “Sustainable Urban Drainage Systems”
- **BMP** – “National Menu of Stormwater Best Management Practices”
- **TDUS** – “TÉCNICAS DE DRENAJE URBANO SOSTENIBLE”

Public Education	1
Public Involvement	2
Illicit Discharge	3
Construction	4
Post-construction	5
Good Housekeeping	6

SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

WATER SENSITIVE URBAN DESIGN (WSUD):

- Represents a new paradigm in the planning and design of urban development that aims to minimise impacts on the natural water cycle and protect the health of aquatic ecosystems.
- Promotes an approach to urban development that responds to a site's natural features, protect natural ecosystems on site and downstream, and optimise the use of water as a precious resource.
- Aims to deliver sustainable water cycle solutions in urban areas.



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

THE GUIDING PRINCIPLES OF WSUD ARE TO:

- Protect existing natural features and ecological processes.
- Maintain natural hydrologic behaviour of catchments.
- Protect water quality of surface and ground waters.
- Minimise demand on the reticulated water supply system.
- Minimise wastewater discharges to the natural environment.
- Integrate water into the landscape to enhance visual, social, cultural and ecological values.

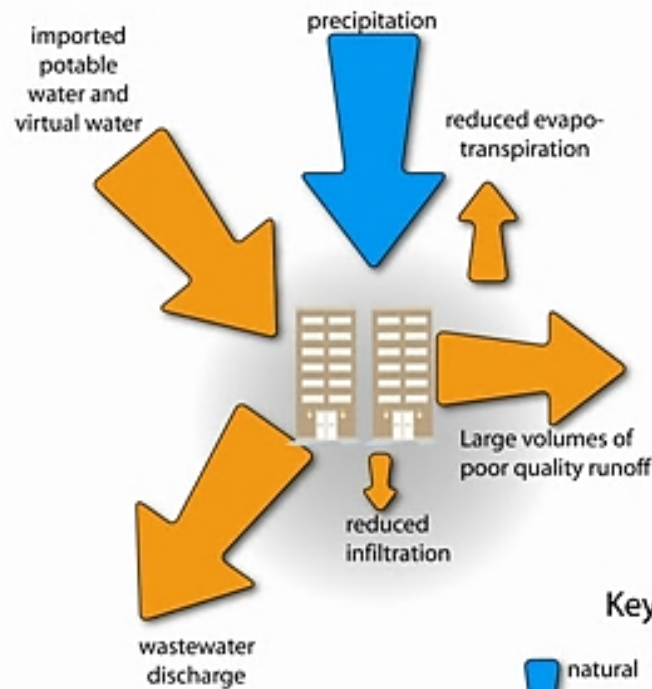


SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

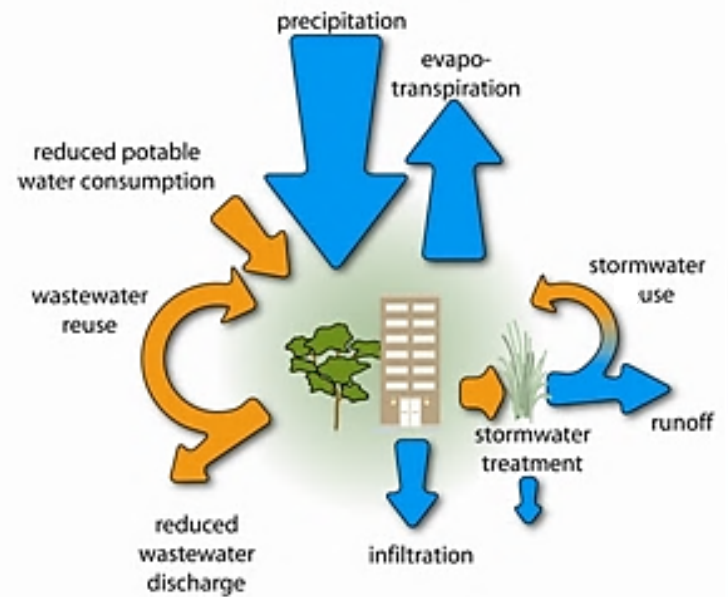
natural water balance



Urban water balance



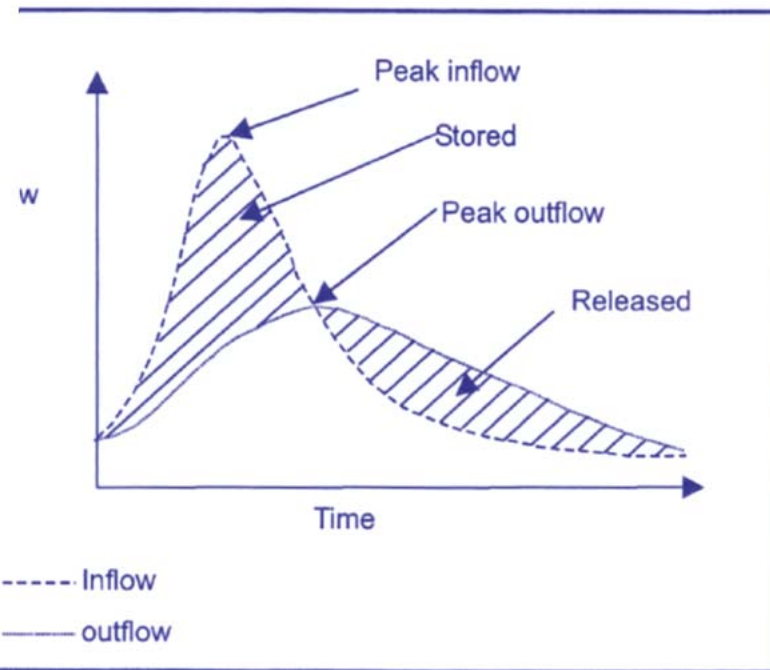
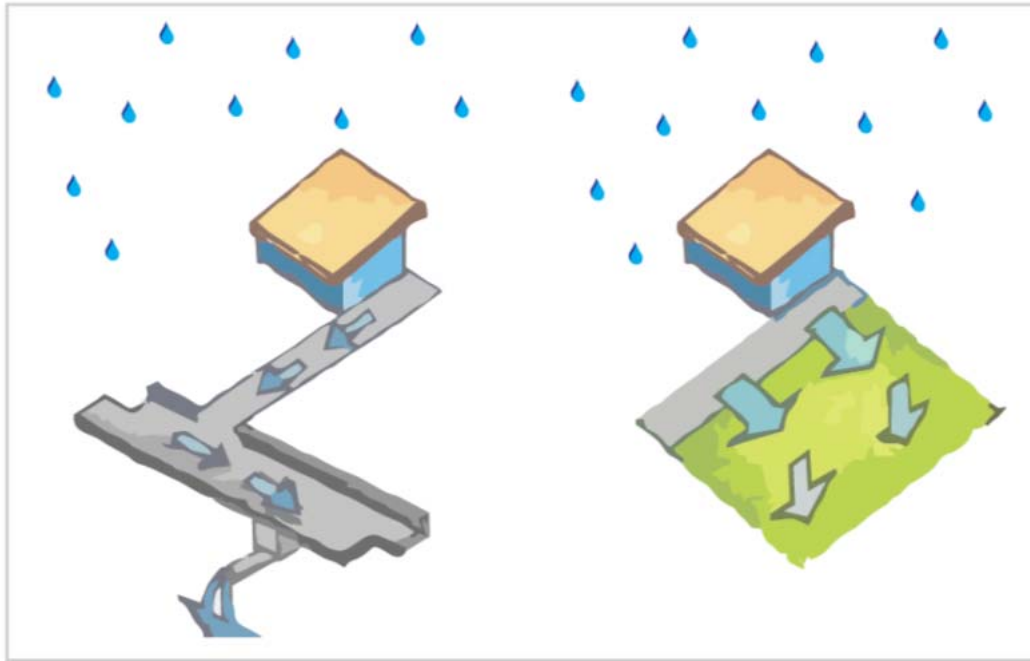
WSUD water balance



Key:



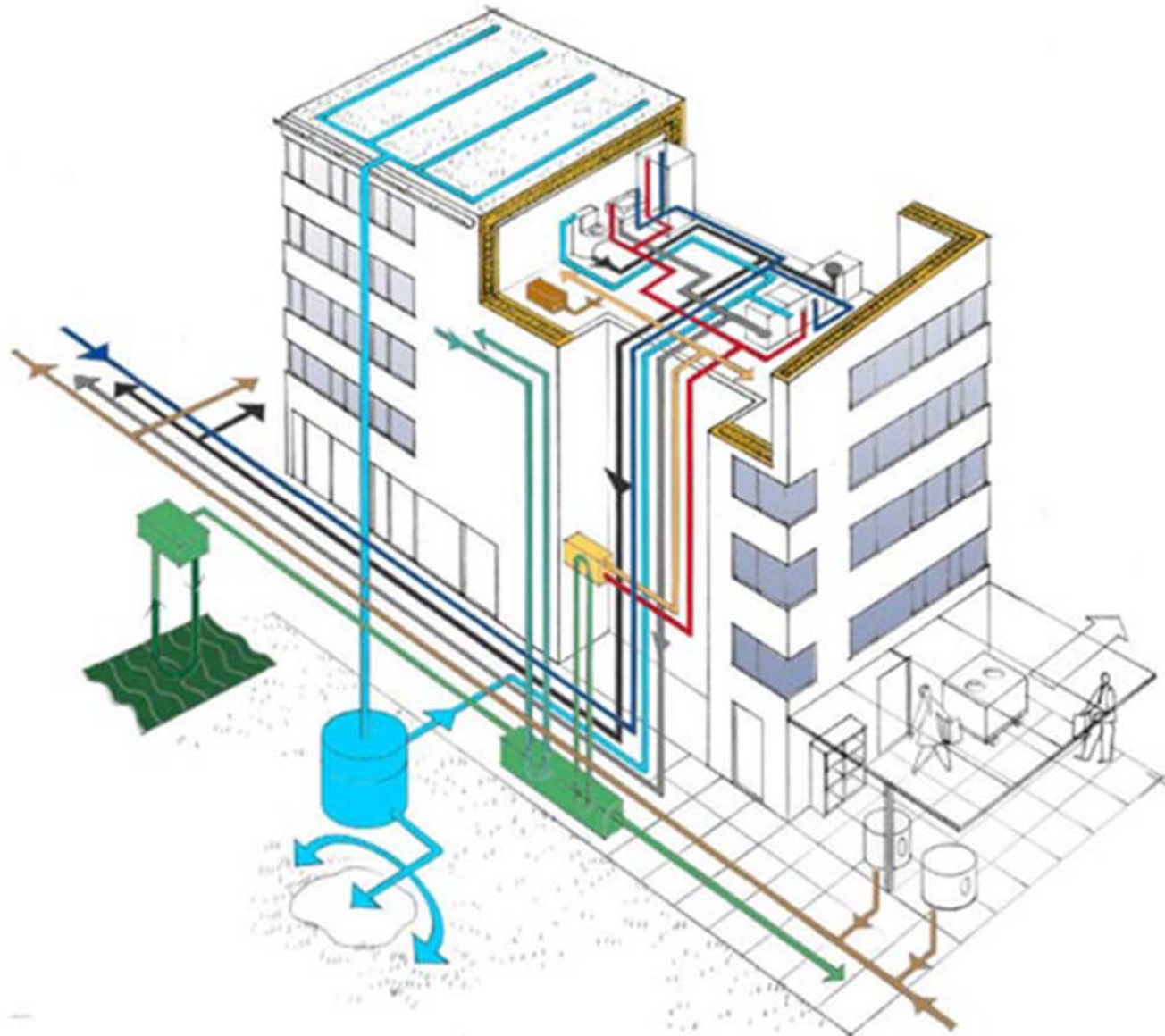
SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



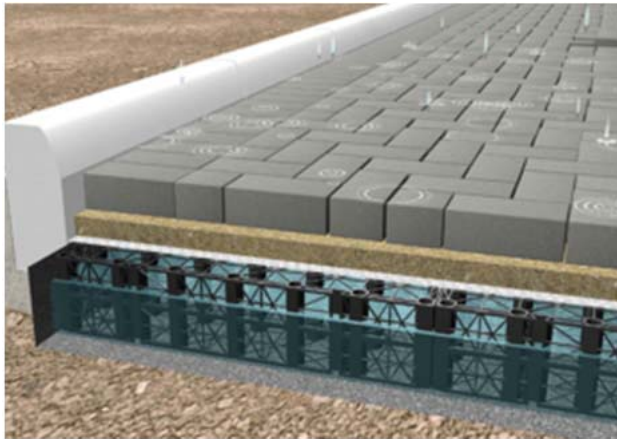
SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



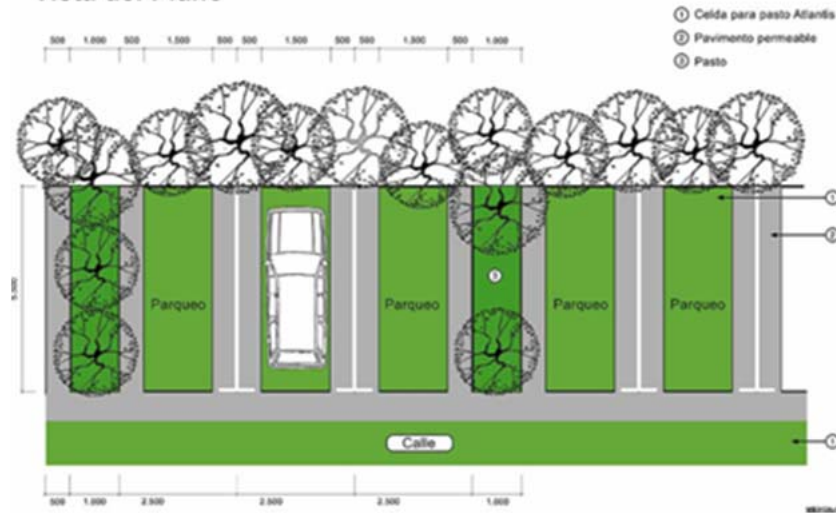
- LOW ENERGY DEMAND**
 - High insulation of walls, windows and roofs, reduced cold bridges, airtight building envelope, controlled ventilat and heat exchange
- ENERGY SUPPLY**
 - Geothermal cooling and Low temperature heating
 - Comfort cooling (non-residential)
 - Heat pump: Hot tap water
 - Pre-heated ventilation air
 - Heat pump utilizing exhaust for tap warm water and/or supply air (optional)
- WATER SUPPLY**
 - from city net
- BLACK WATER**
 - from wc and slurry from waste-disposer
- GREY WATER**
 - from bath and kitchen
- STORM WATER**
 - Reuse for wc and dishwasher
- WASTE**
 - Vacuum transportation
- ALL SYSTEMS**

SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

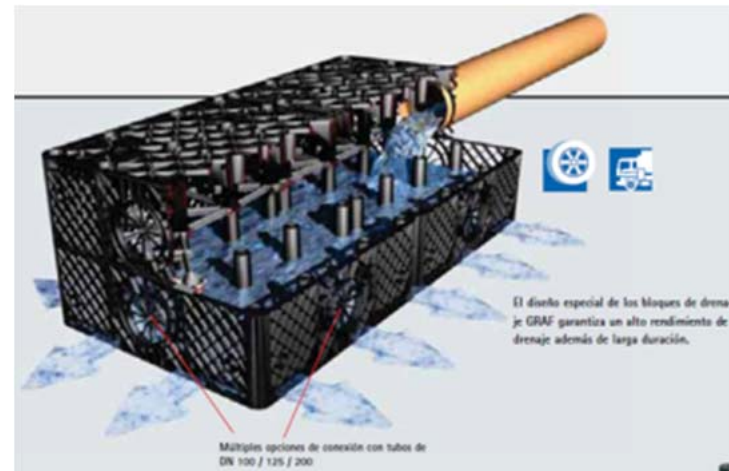
FILTER DRAINS/PAVEMENT SUB-BASE



Vista del Plano



SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

FILTER STRIPS/TREATMENT SWALES

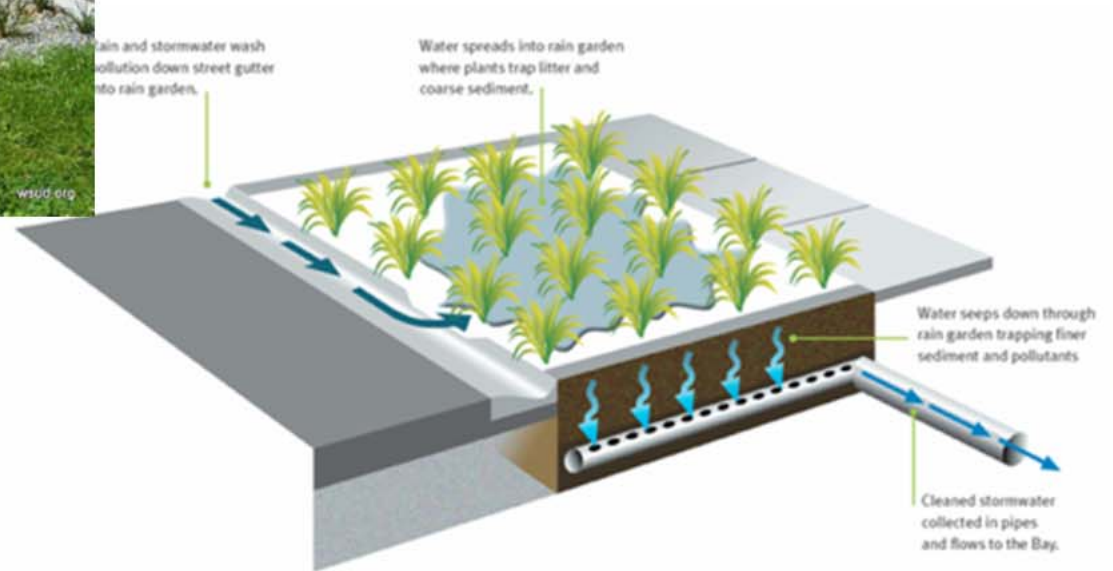


SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

EXTENDED DETENTION BASINS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

RETENTION PONDS

WETLANDS

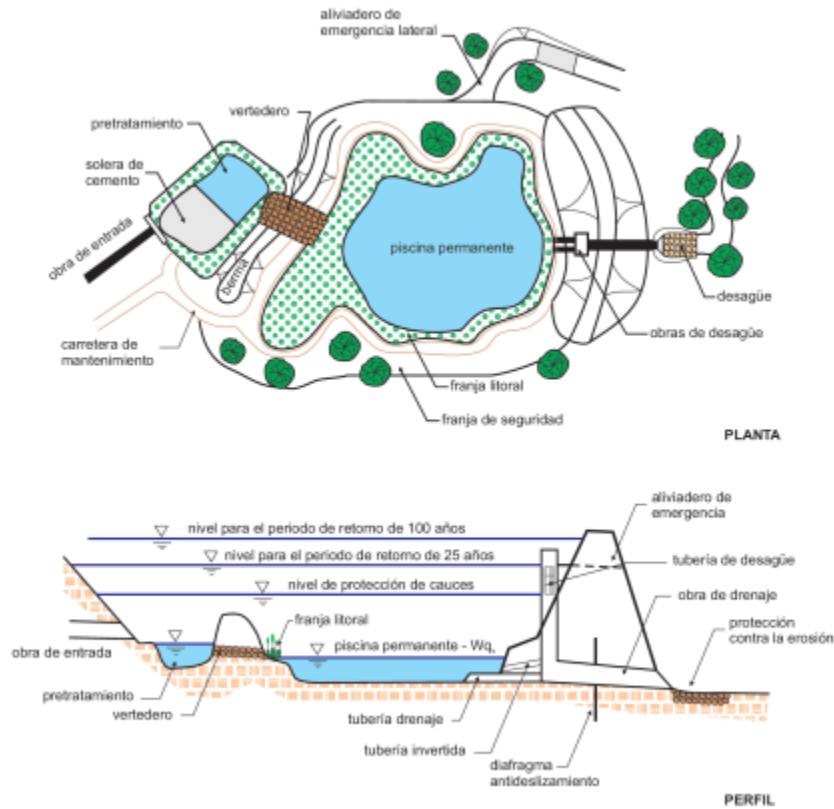


Figura 10. Esquema de un estanque de retención húmedo (ARC, 2001)



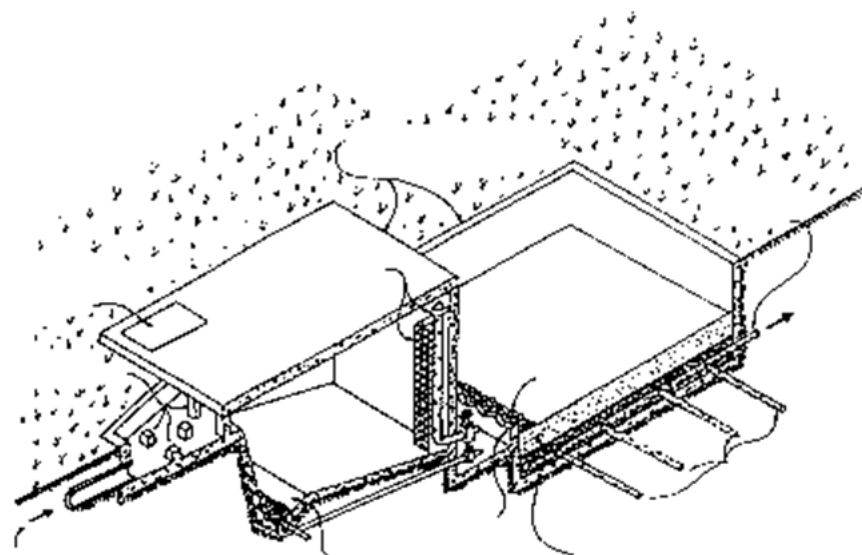
SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



COMPONENTES DEL CICLO DEL AGUA URBANA “AVANZADO” (17)

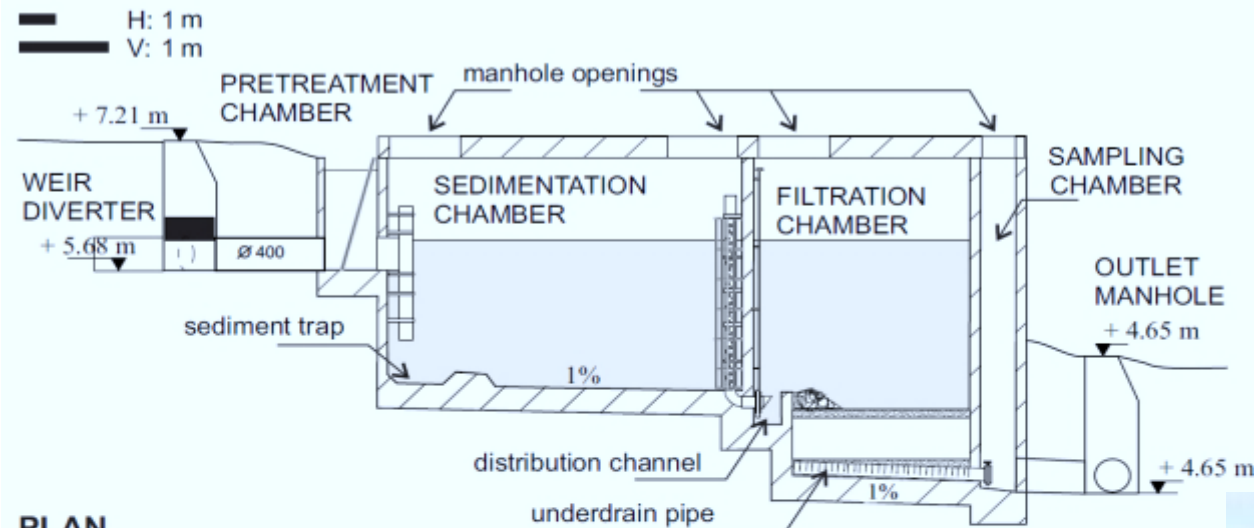


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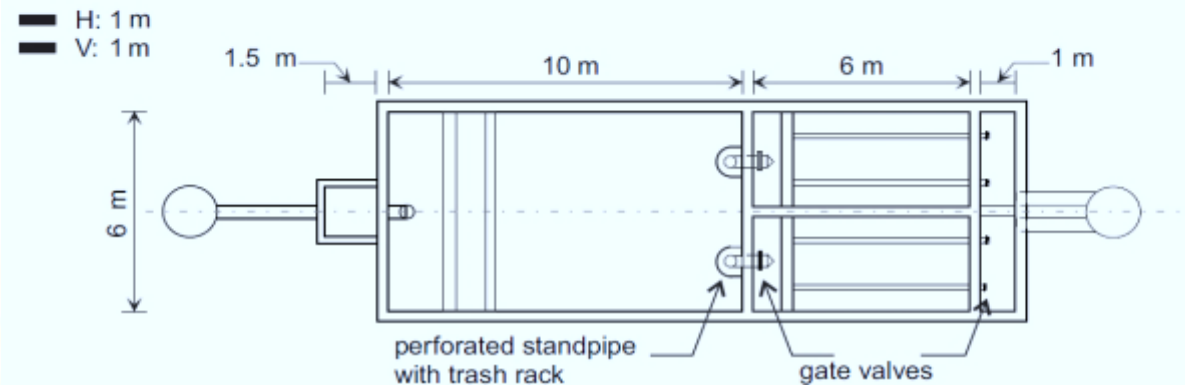


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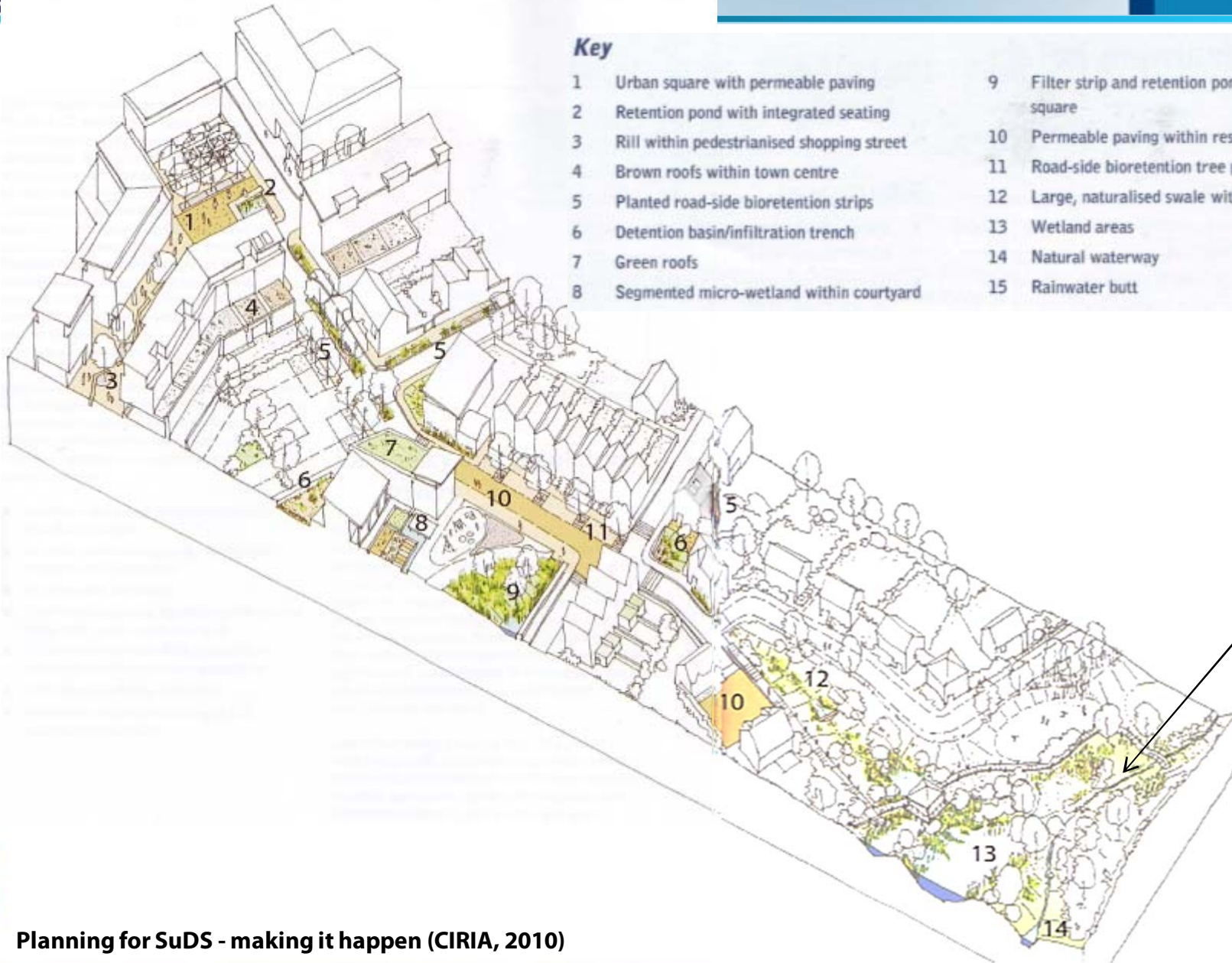
SIDE VIEW



PLAN



- TDUS built in FENE – Galicia (SPAIN) for road runoff.



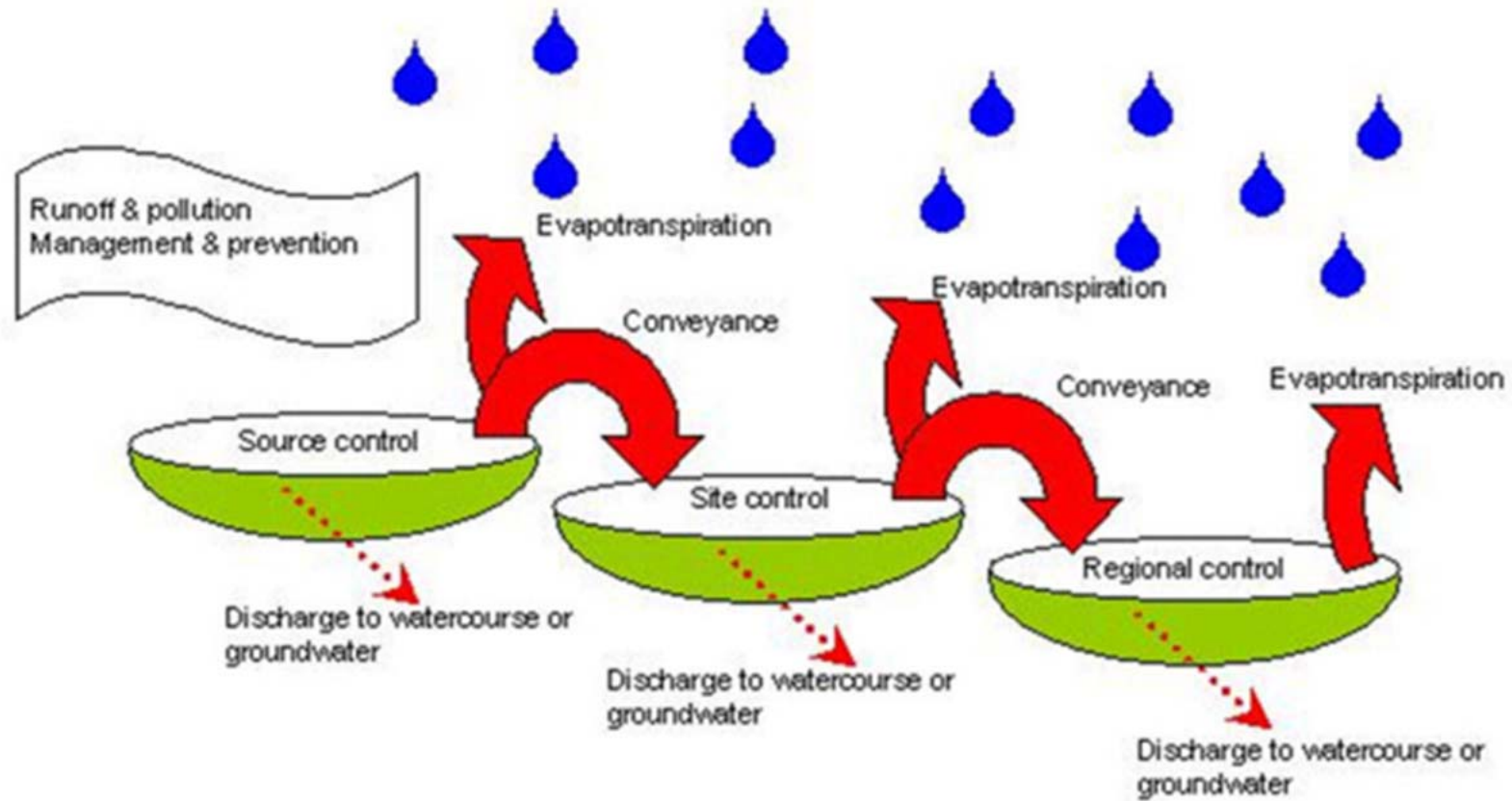
Key

- | | |
|--|---|
| 1 Urban square with permeable paving | 9 Filter strip and retention pond within residential square |
| 2 Retention pond with integrated seating | 10 Permeable paving within residential street/mews |
| 3 Rill within pedestrianised shopping street | 11 Road-side bioretention tree pits |
| 4 Brown roofs within town centre | 12 Large, naturalised swale within green space |
| 5 Planted road-side bioretention strips | 13 Wetland areas |
| 6 Detention basin/infiltration trench | 14 Natural waterway |
| 7 Green roofs | 15 Rainwater butt |
| 8 Segmented micro-wetland within courtyard | |

NATURAL WATERWAY

Planning for SuDS - making it happen (CIRIA, 2010)

SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



The SuDS management train

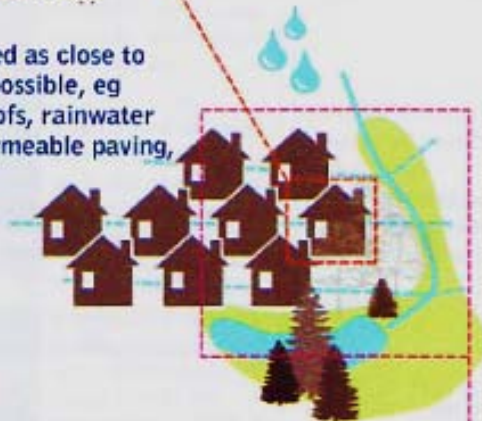


1 Prevention

Good housekeeping and site design to reduce and manage runoff and pollution, eg land-use planning, reduction of paved surfaces

2 Source control

Runoff managed as close to the source as possible, eg using green roofs, rainwater harvesting, permeable paving, filter strips



3 Site control

Runoff managed in a network across a site or local area, eg using swales, detention basins, public realm SuDS components for attenuation and treatment. Also, flow should be slowed using overland conveyed routes

4 Regional control

Downstream management of runoff for a whole site/catchment, eg retention ponds, wetlands



The SuDS management train



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS

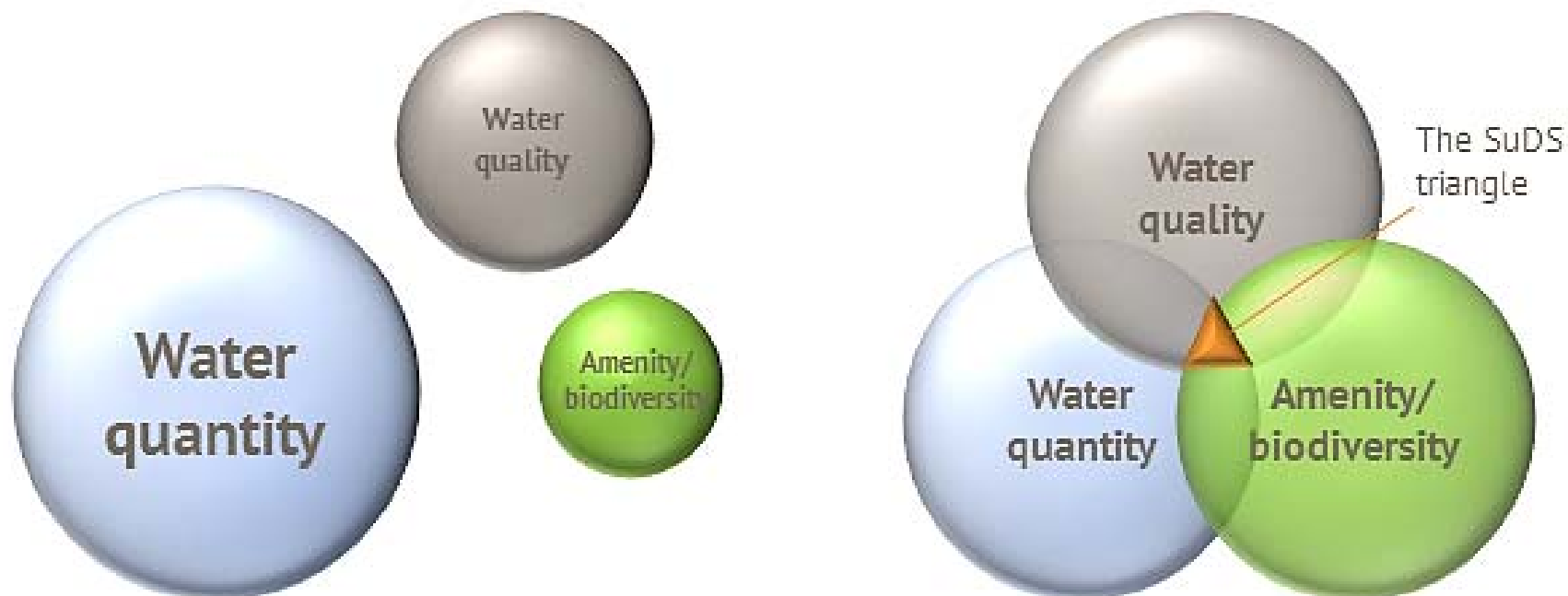
Device	Residential	Non-residential	Industrial
Prevention	*	*	*
Containment	–	–	1
Permeable surfaces	1	1	1 (contained)
Filter strips/treatment swales	1	1	2
Filter drains/pavement sub-base	1	1 or 2	2 (contained)
Swales	1	1 or 2	2
Extended detention basins	1	2	2
Soakaways/infiltration trenches	1	2	3
Infiltration basins	1	2	3
Retention ponds	1	2	3
Wetlands	1	2	3
Levels of treatment required	1	2	3

Key

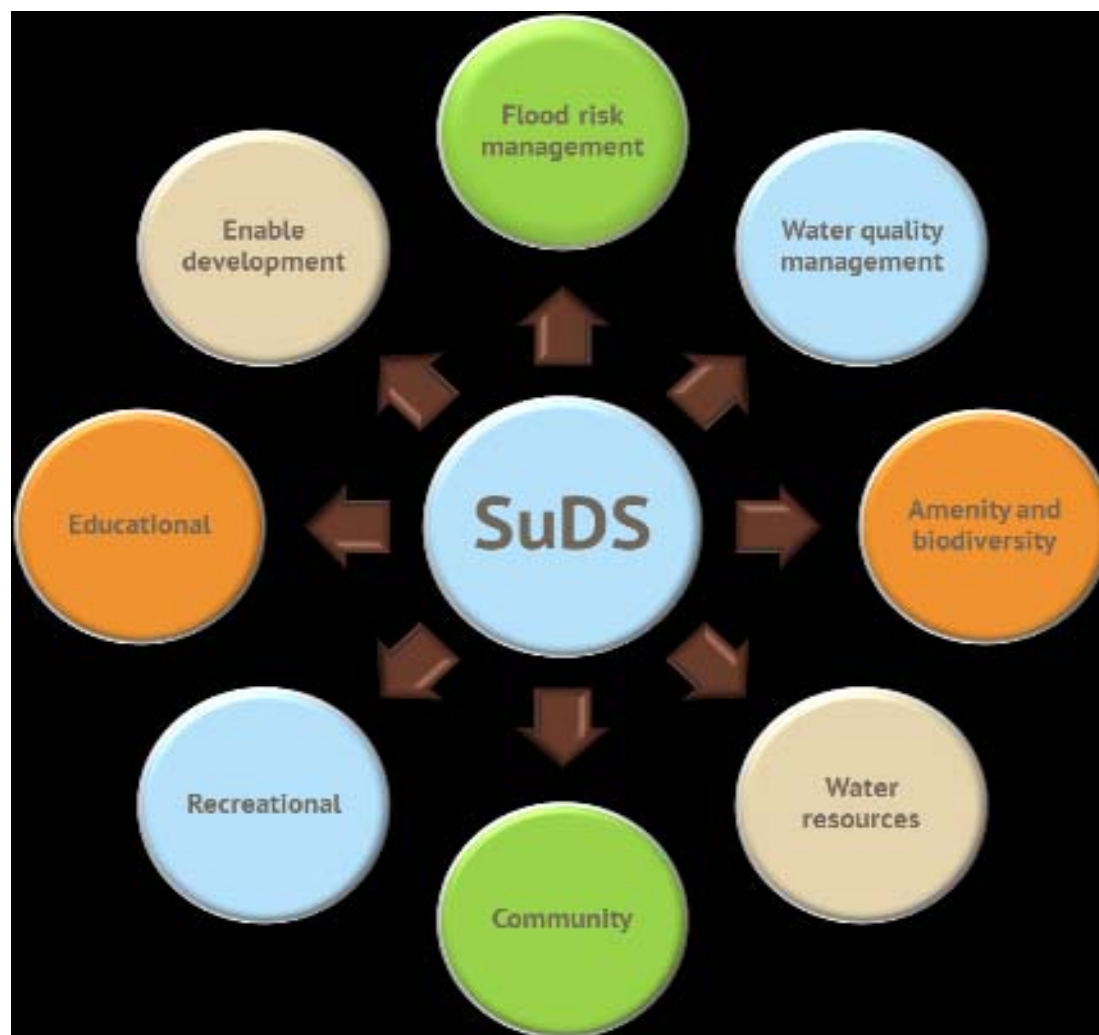
- * – always required
- 1 – first level of treatment
- 2 – second level of treatment
- 3 – third level of treatment



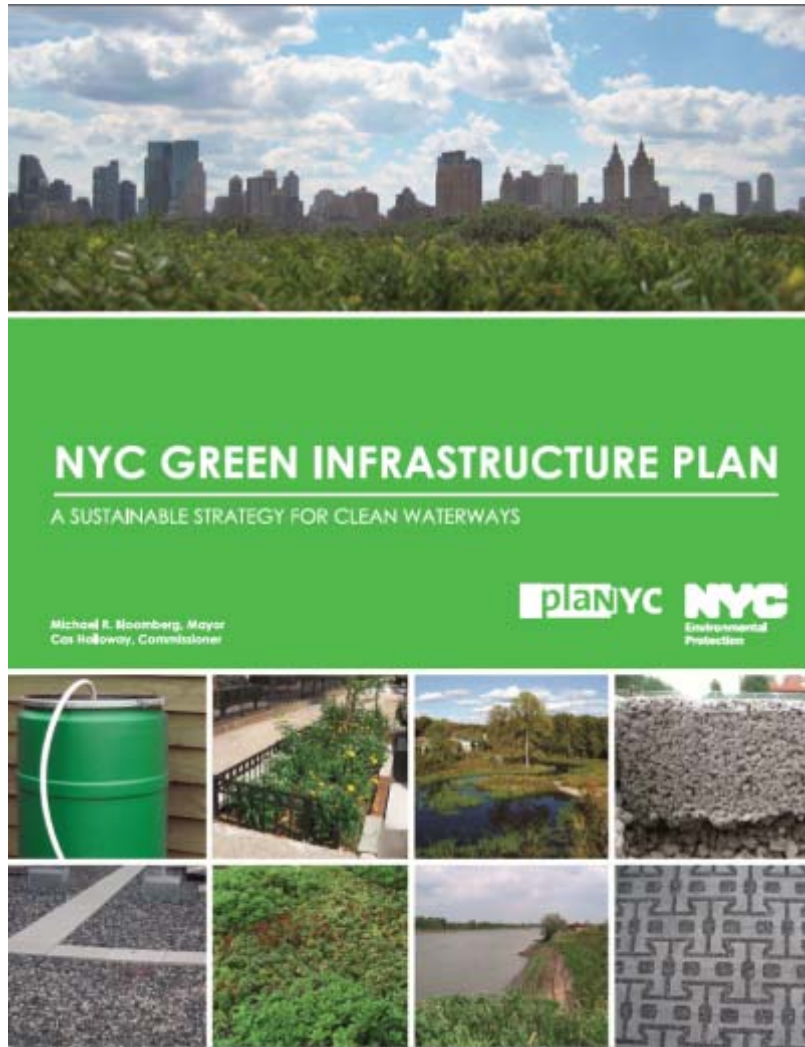
SUSTAINABLE URBAN DRAINAGE TECHNIQUES - TDUS



SUSTAINABLE URBAN DRAINAGE TECHNIQUES – TDUS / SUDS



INTEGRATED WATERCYCLE MANAGEMENT




ITOHG-SAN-1/4


**INSTRUCCIÓN TÉCNICAS
PARA OBRAS HIDRÁULICAS
EN GALICIA**

SERIE SANEAMIENTO


TÍTULO	TÉCNICAS DE DRENAXE URBANA SOSTIBLE (SAN-1/4)
Data de elaboración	Novembro de 2009
Revisión visante	Novembro de 2009



XUNTA DE GALICIA
CONSELLERÍA DE MEDIO AMBIENTE,
TERRITORIO E INFRAESTRUTURAS



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EPOSH

Monografías

Gestión de las aguas pluviales
Implicaciones en el diseño de los sistemas
de saneamiento y drenaje urbano








DEPUTACIÓN
DA CORUÑA

**gestión de las aguas
pluviales en ámbito
urbano mediante
técnicas de drenaje
sostenible**

mandeo

paraíso fluvial



CONCLUSIONS

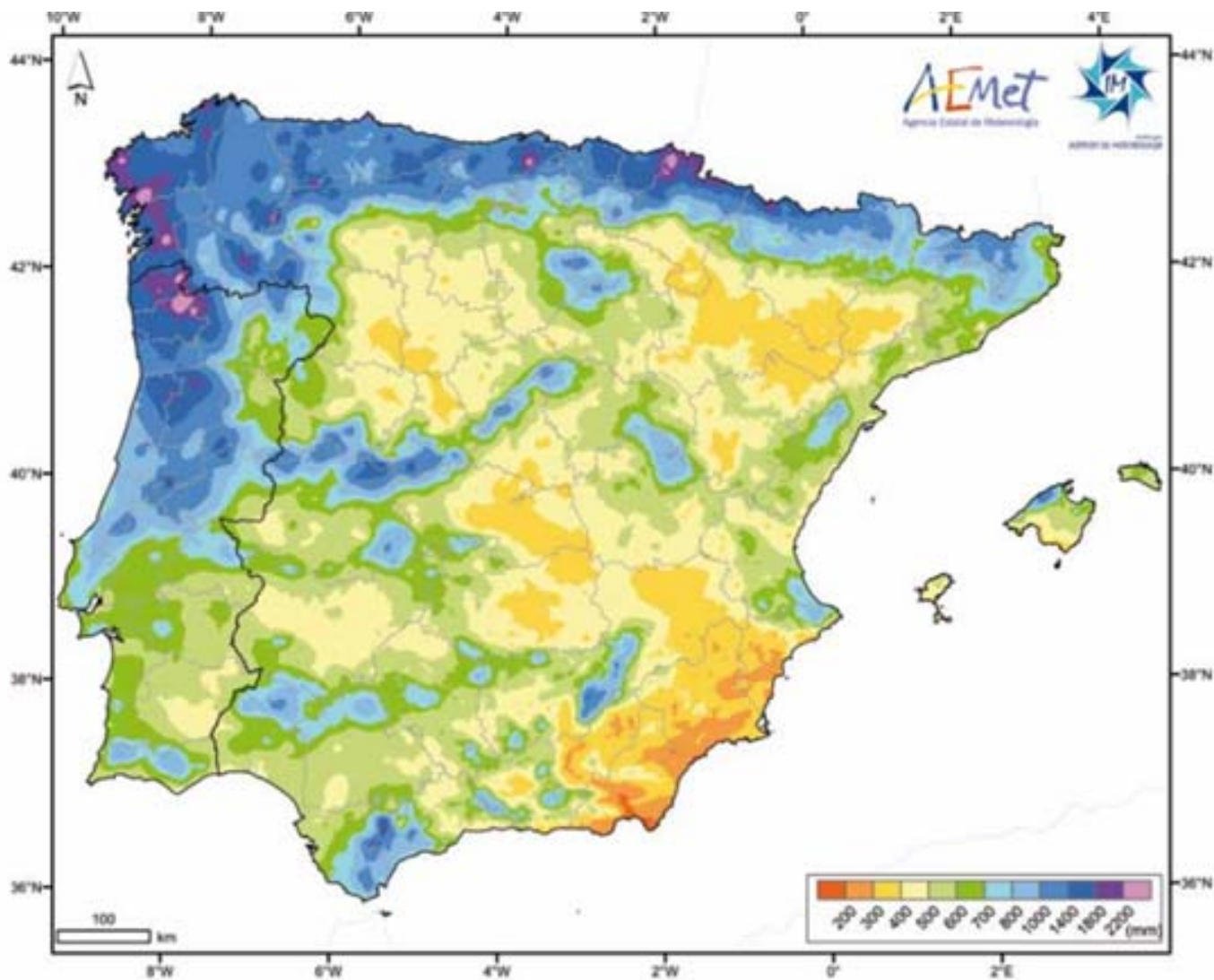
- WE NEED A CHANGE IN OUR WAY TO DEVELOP.
- THE WATER CYCLE IS FUNDAMENTAL PART IN OUR URBAN ENVIRONMENT.
- THE **WSUD** AND **TDU**s ARE VALID STRATEGIES FOR INCORPORATING IN NEW URBAN DEVELOPMENTS.
- ALSO APPLY TO PROCEED TO REHABILITATION URBAN HYDROLOGY.
- CIVIL ENGINEERING HAS A KEY ROLE IN THE WATER SENSITIVE URBAN DESIGN.



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Annual average precipitation