2019

LISBON CES

CIVIL ENGINEERING SUMMIT

24 - 28 SEPTEMBER 2019, LISBOA, PORTUGAL

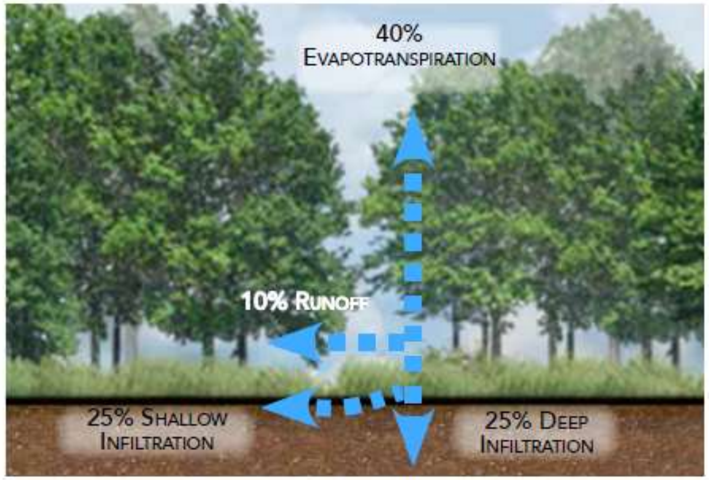
Sustainable drainage grids

Sara Perales Momparler

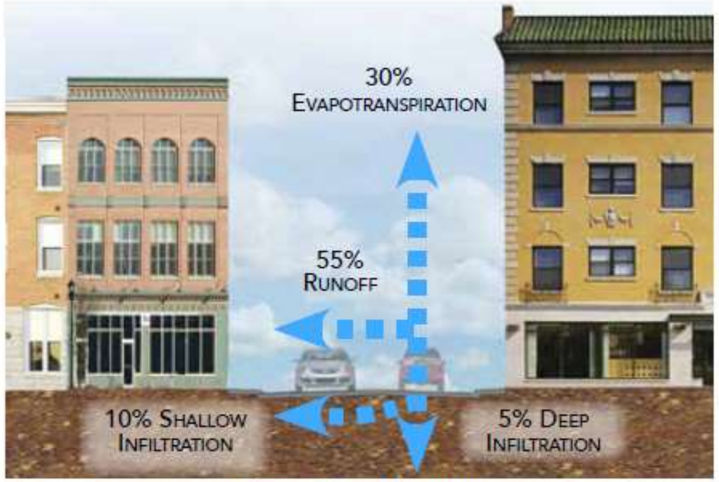
1. Current challenges
2. Paradigm shift in urban drainage: SUDS
3. Spanish experiences in SUDS

Conclusions

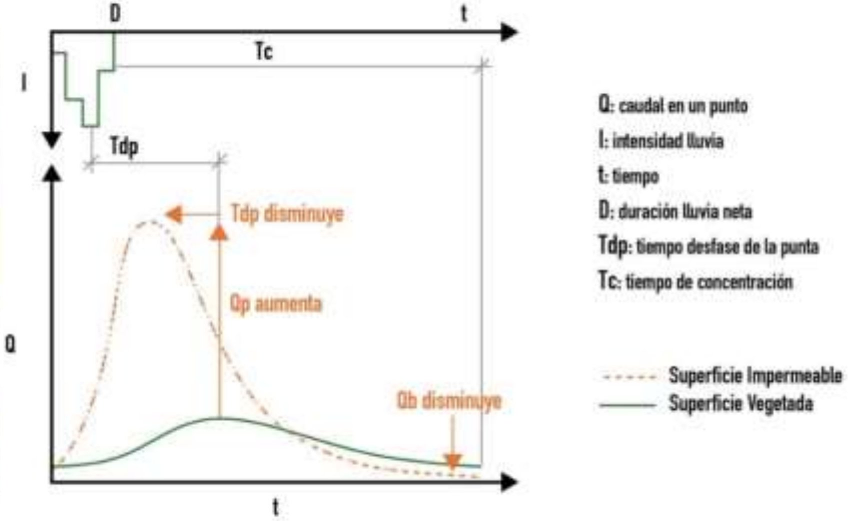
Soil sealing: peak flow increase, lower concentration time, …



Natural Area Diagram

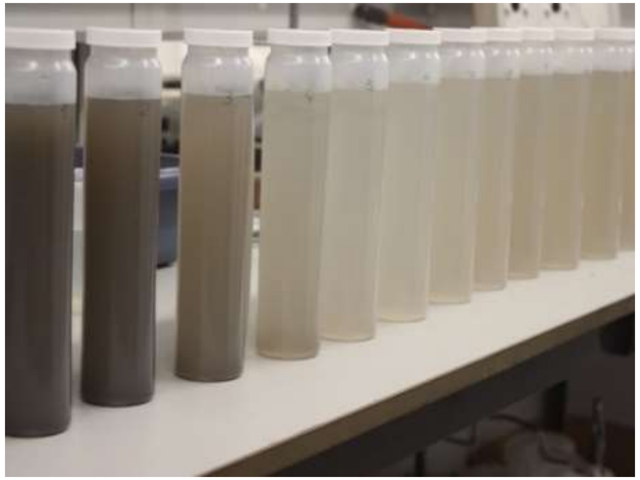


Urban Area Diagram



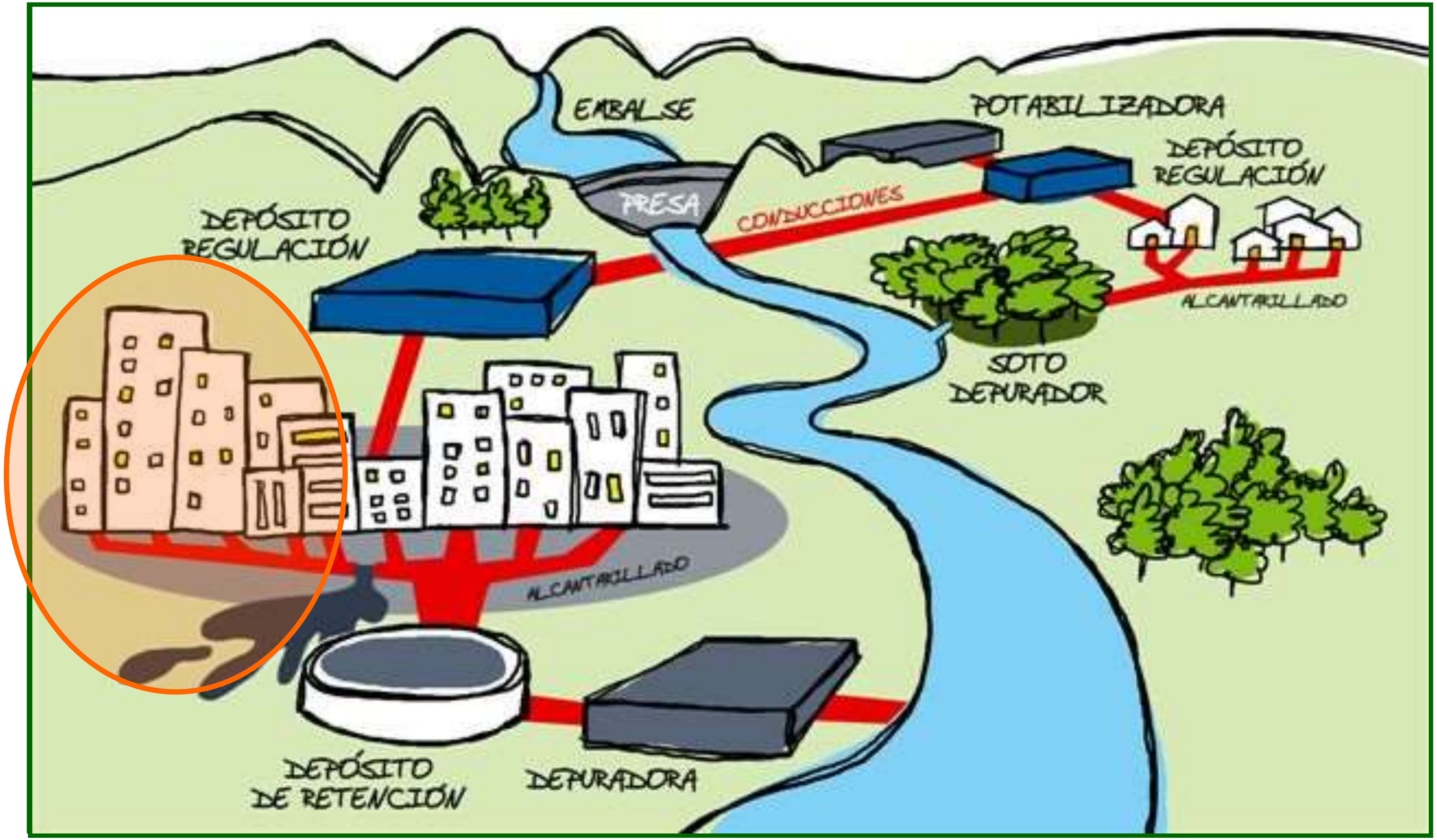
Floods and sewer network overflows

Stormwater pollution and combined sewer overflows



Energy consumption in stormwater management, few space for biodiversity, discomfort for citizens after raining, …



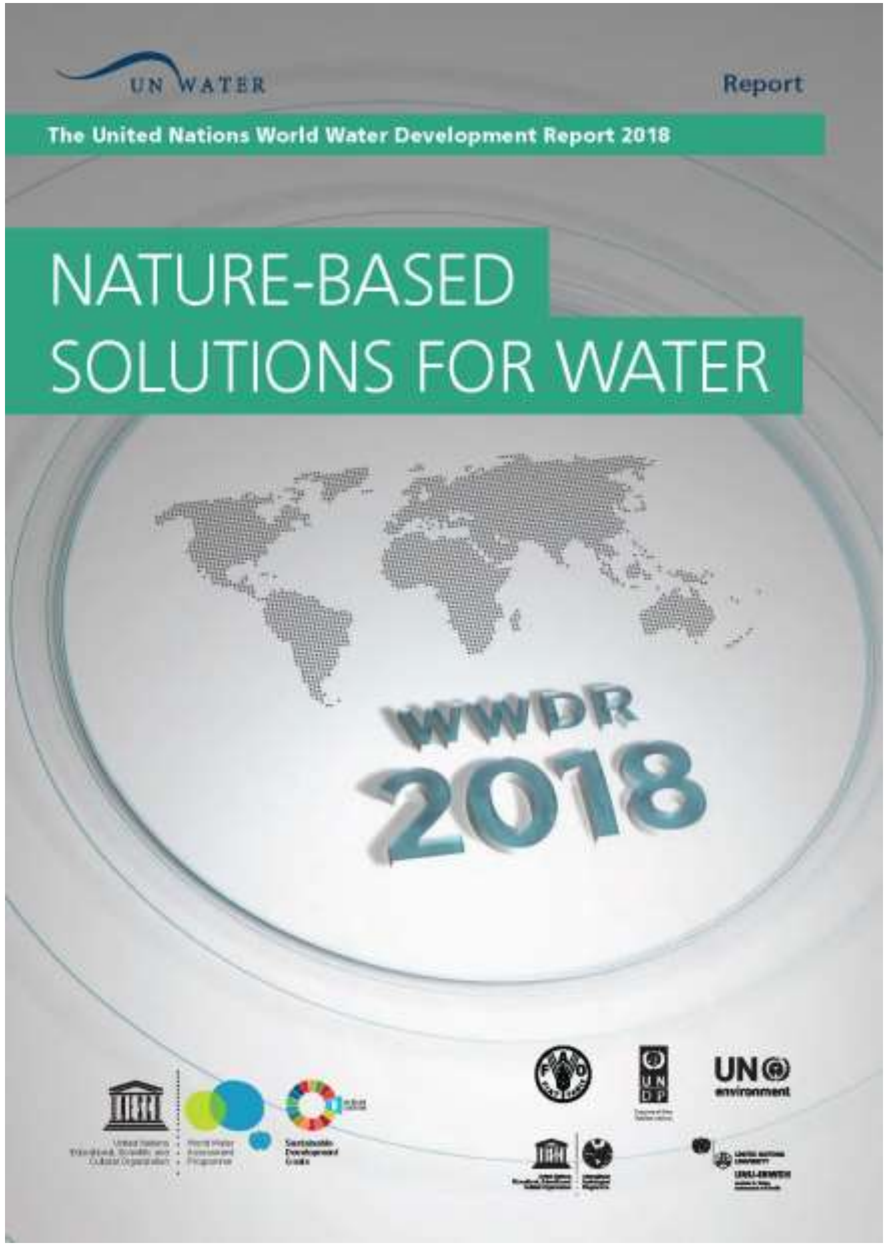


EMBALSE
POTABILIZADORA
DEPÓSITO REGULACIÓN
PRESA
CONDUCCIONES
DEPÓSITO REGULACIÓN
ALCANTARILLADO
SOTO DEPURADOR
ALCANTARILLADO
DEPÓSITO DE RETENCIÓN
DEPURADORA

- **Goal 6: Clean water and sanitation:**
  - Improve water quality by **reducing pollution**
  - Substantially increase **water-use efficiency** of water resources
- **Goal 11: Sustainable cities and communities**
  - Substantially decrease […] water-related disasters
- **Goal 13: Climate action**
  - Strengthen resilience and **adaptive** capacity to climate-related hazards and natural disasters

ODS

SUDS

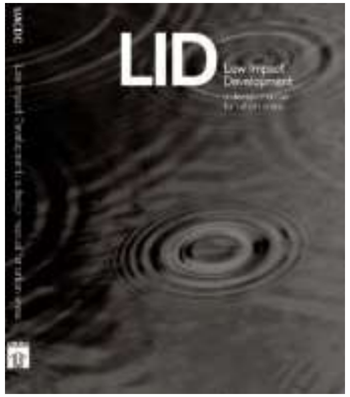


The 2018 UN World Water Development Report proposes an innovative response to water resource management challenges:

nature-based solutions (NBS)

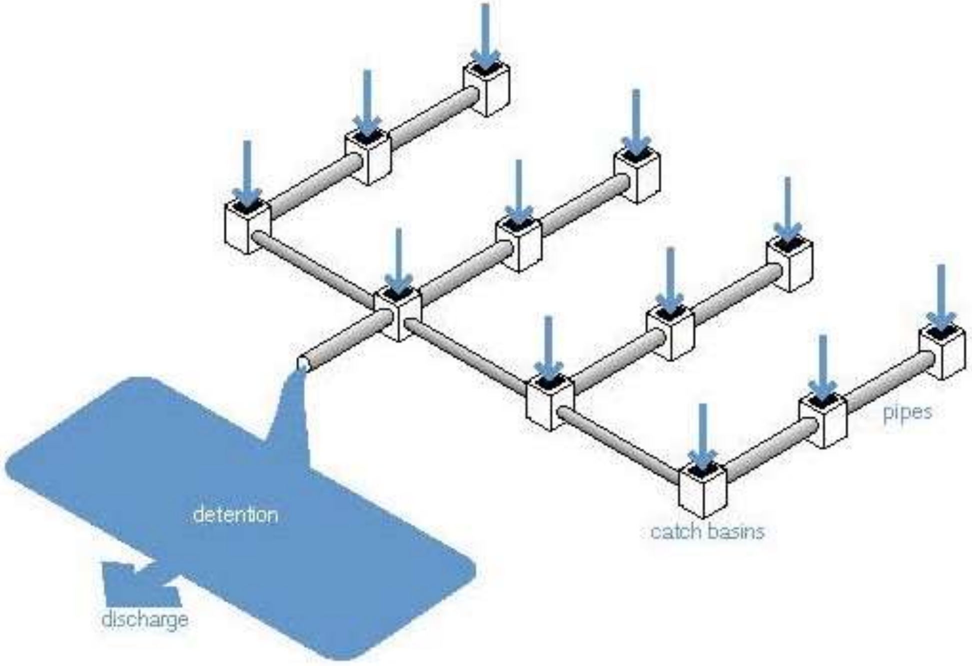
NBS uses or mimics natural processes to:

- enhance water availability (e.g. soil moisture retention, groundwater recharge),
- improve water quality (e.g. natural and constructed wetlands, riparian buffer strips), and
- reduce risks associated with water-related disasters and climate change (e.g., floodplain restoration, green roofs).



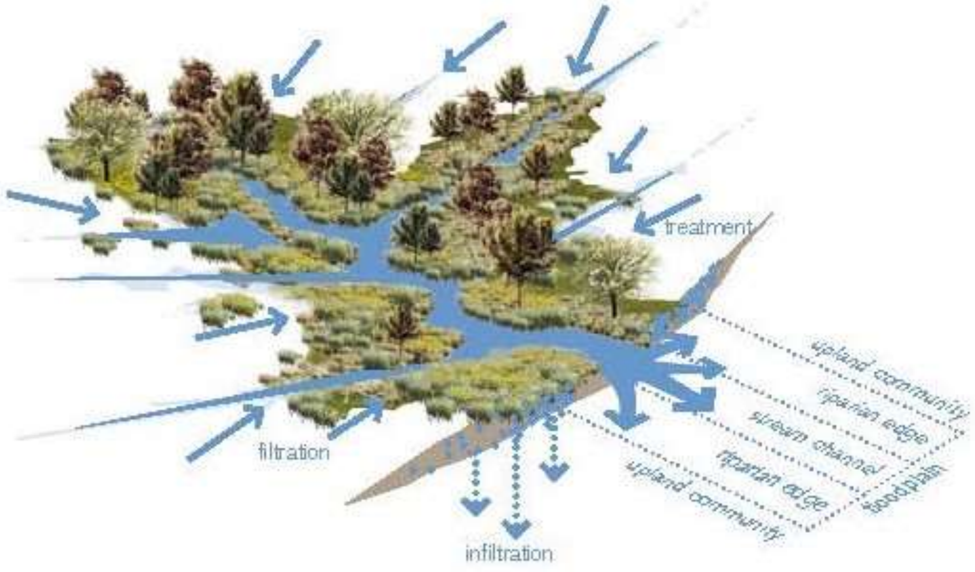
Paradigm shift in urban drainage:

hard engineering
...just transfers pollution
to another site

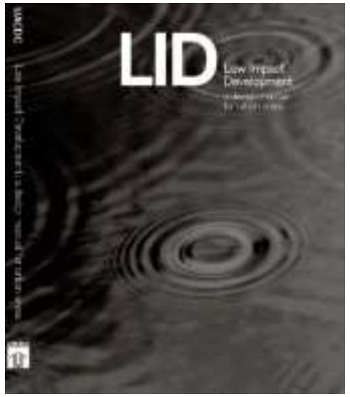


conventional management: "pipe-and-pond" infrastructure
drain, direct, dispatch

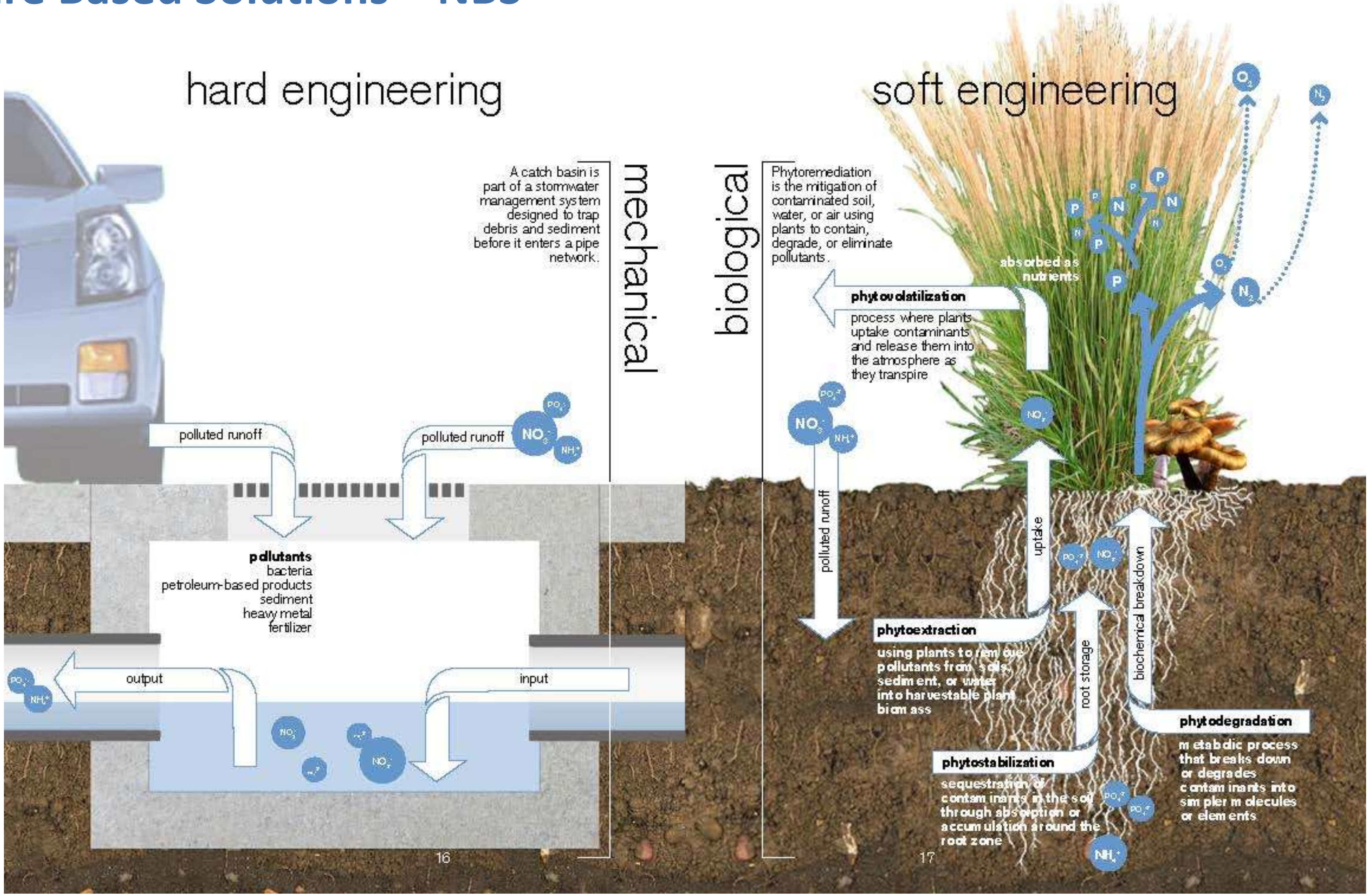
soft engineering
...metabolizes pollutants
on site—parks, not pipes!



low impact management: watershed approach
slow, spread, soak



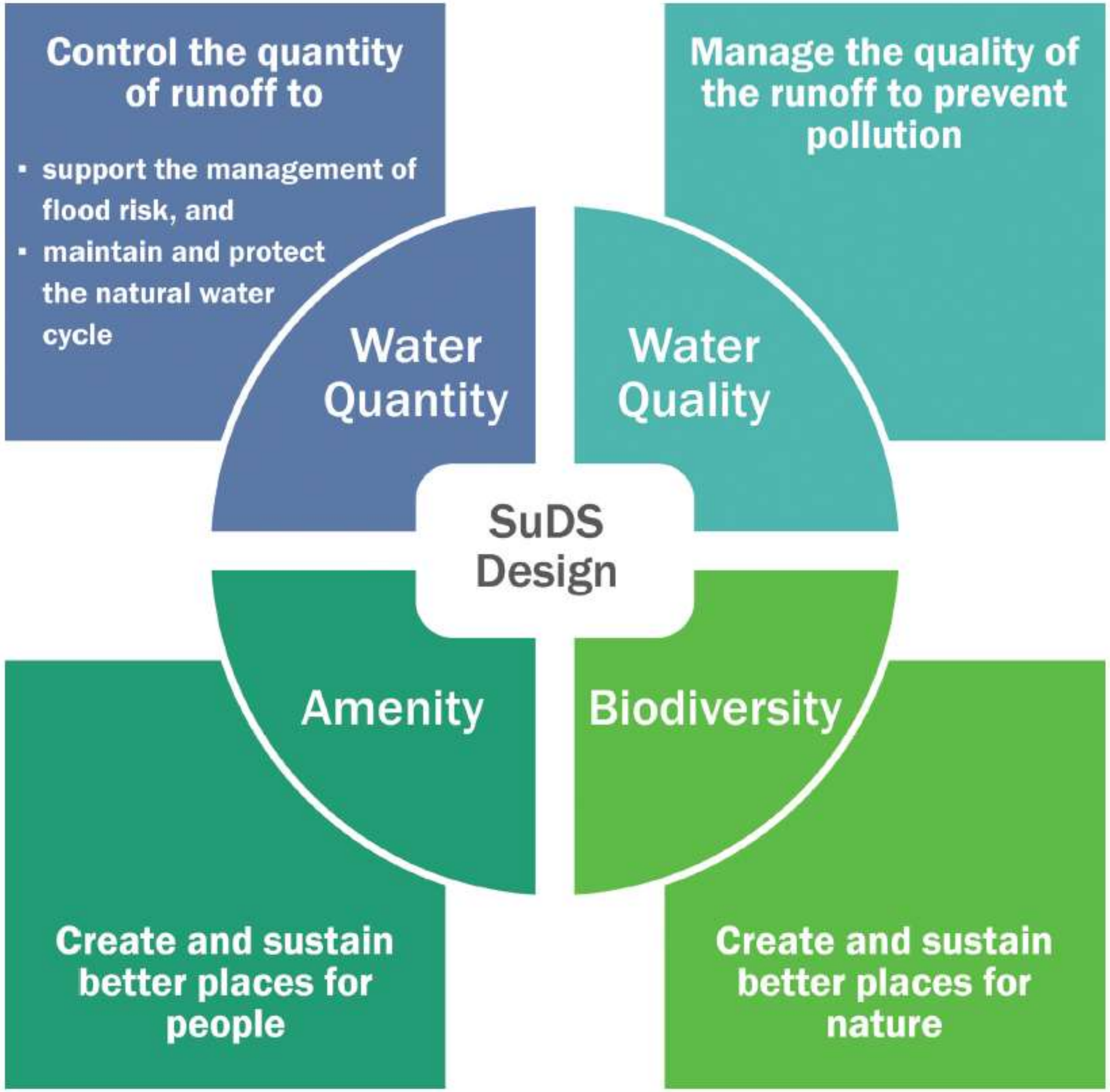
Nature Based Solutions – NBS



SUDS – Sustainable Urban Drainage System

"Innovative" strategy for stormwater management and urban planning that seeks reproduce / restore the hydrological processes previous to urban development (filtering, storage, evapotranspiration, infiltration...), strategically integrating elements of runoff control in the urban landscape

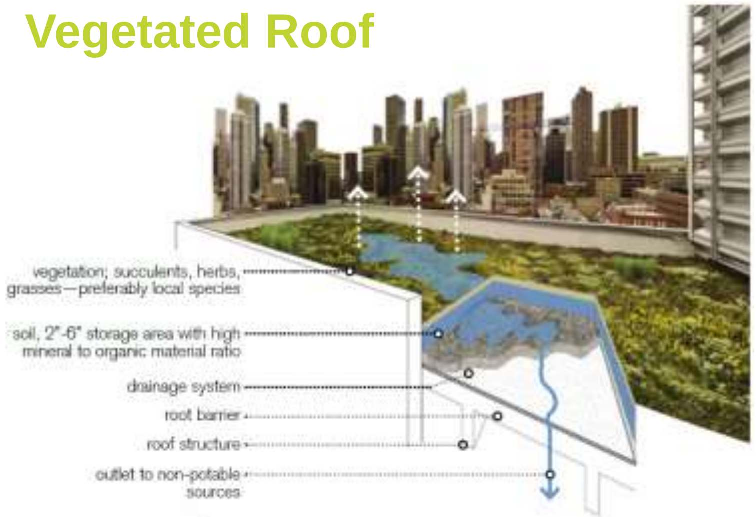
2. Paradigm shift in urban drainage: SUDS



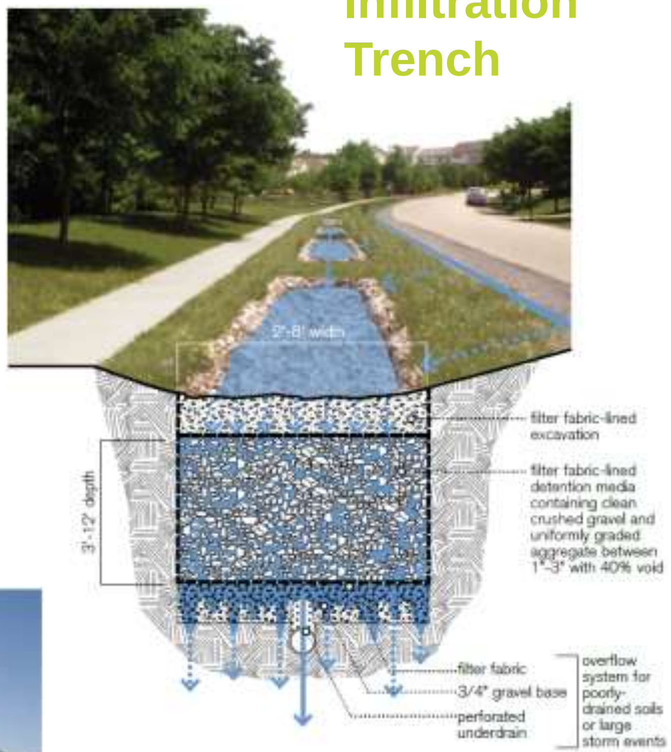
Sustainable drainage grids

2. Paradigm shift in urban drainage: SUDS

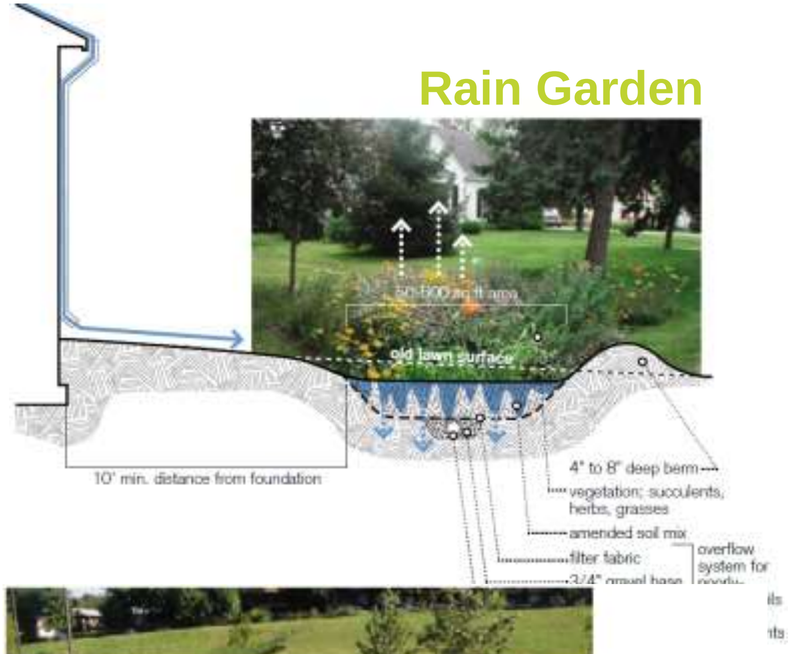
Vegetated Roof



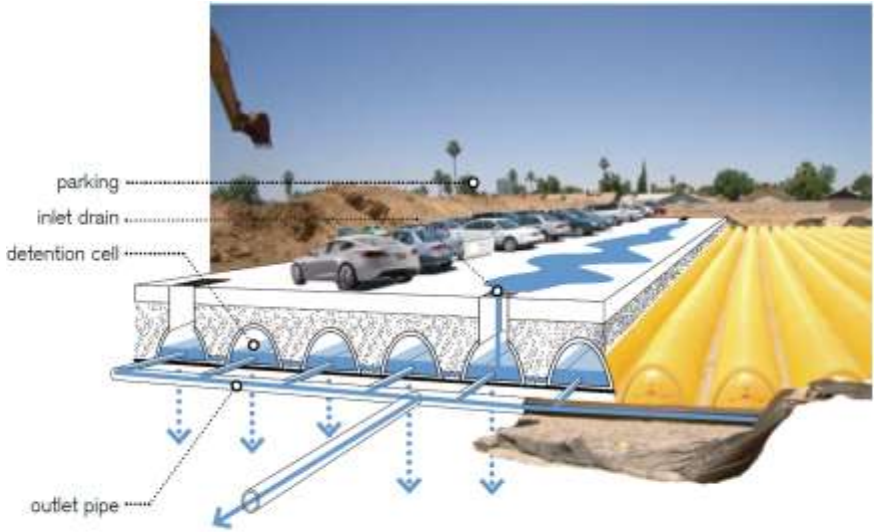
Infiltration Trench



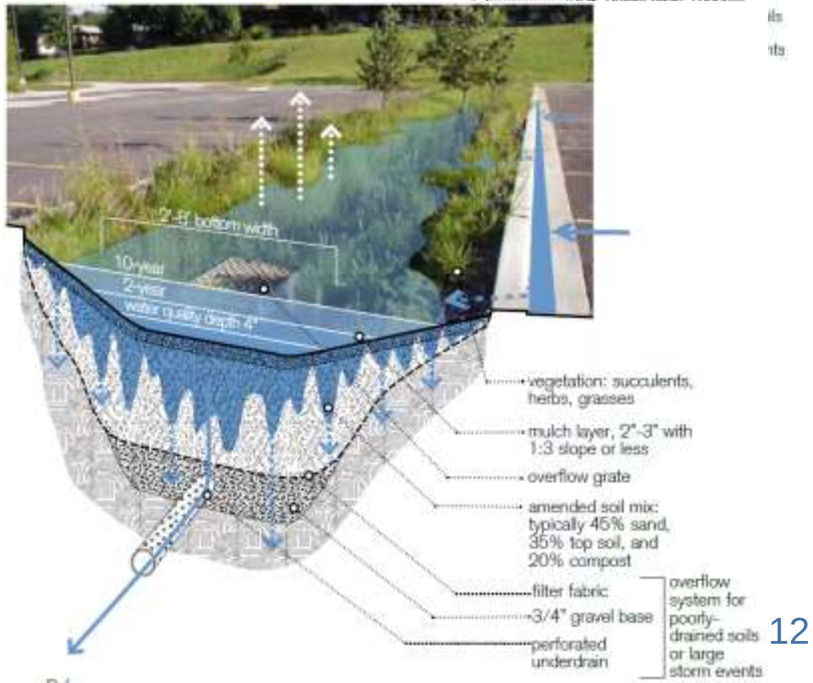
Rain Garden



Underground Detention



Bioretention Area



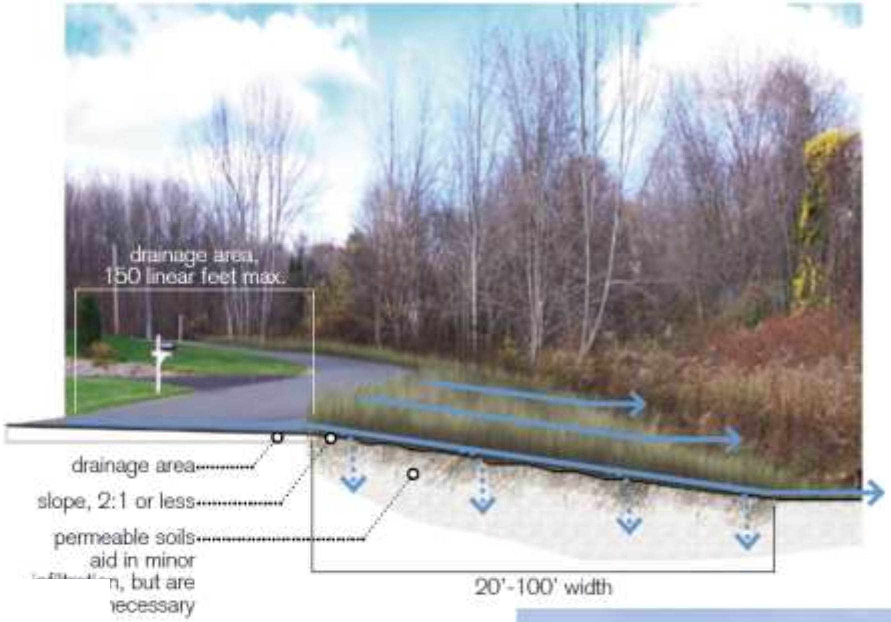
University of Arkansas Community Design Center (2010). *LID Low Impact Development a design manual for urban areas*. US Environmental Protection Agency & Arkansas Natural Resources Commission. USA.

Sustainable drainage grids

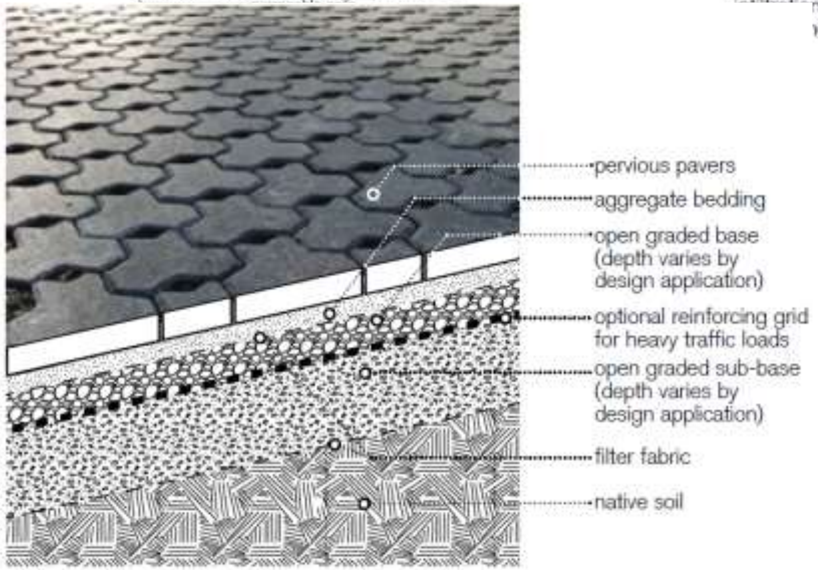
2. Paradigm shift in urban drainage: SUDS

Dry Swale

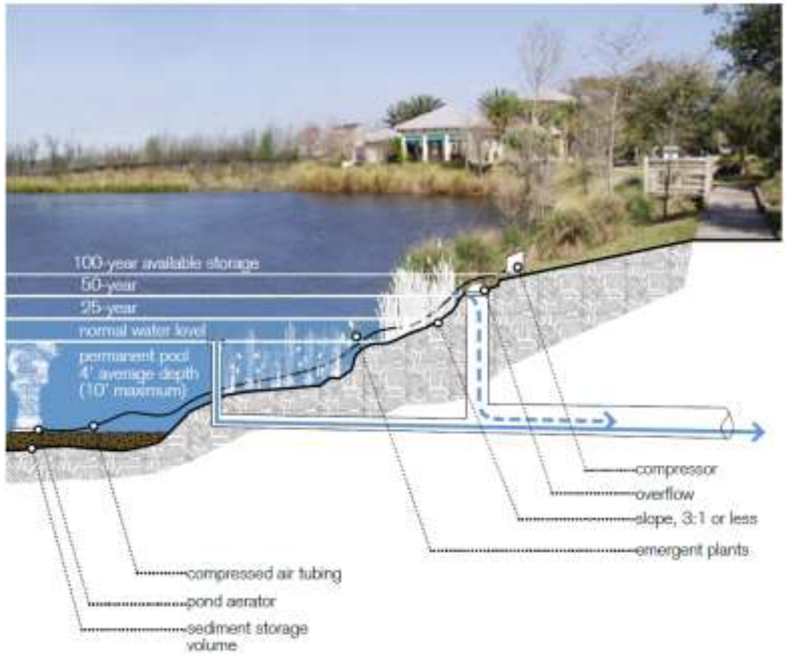
Filter Strip



Permeable Paving



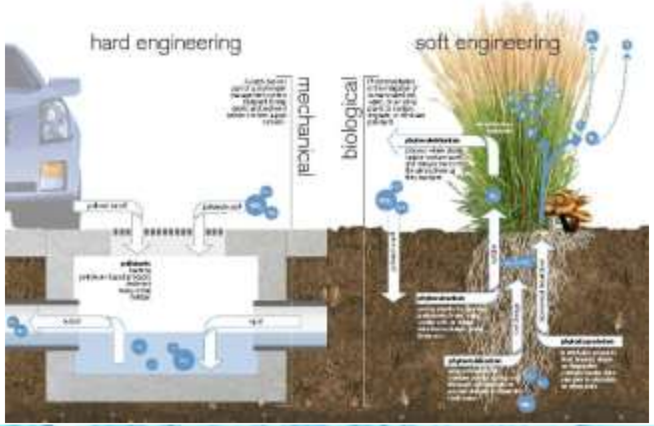
Retention Pond



University of Arkansas Community Design Center (2010). *LID Low Impact Development a design manual for urban areas*. US Environmental Protection Agency & Arkansas Natural Resources Commission. USA.

2. Paradigm shift in urban drainage: SUDS

- **Nature Based Solution** (NBS)
- **Decentralised** management
- Management **focused on citizens**: **educational opportunities**



- Stormwater is a **natural resource** (not a waste)
- **Integration** in urban landscape
- **Multifunctional spaces**
- **Diversity** of techniques
- **Specific** solutions for each place
- LEED, BREEAM… credits

From linear economy (produce, use, dispose) → to circular economy

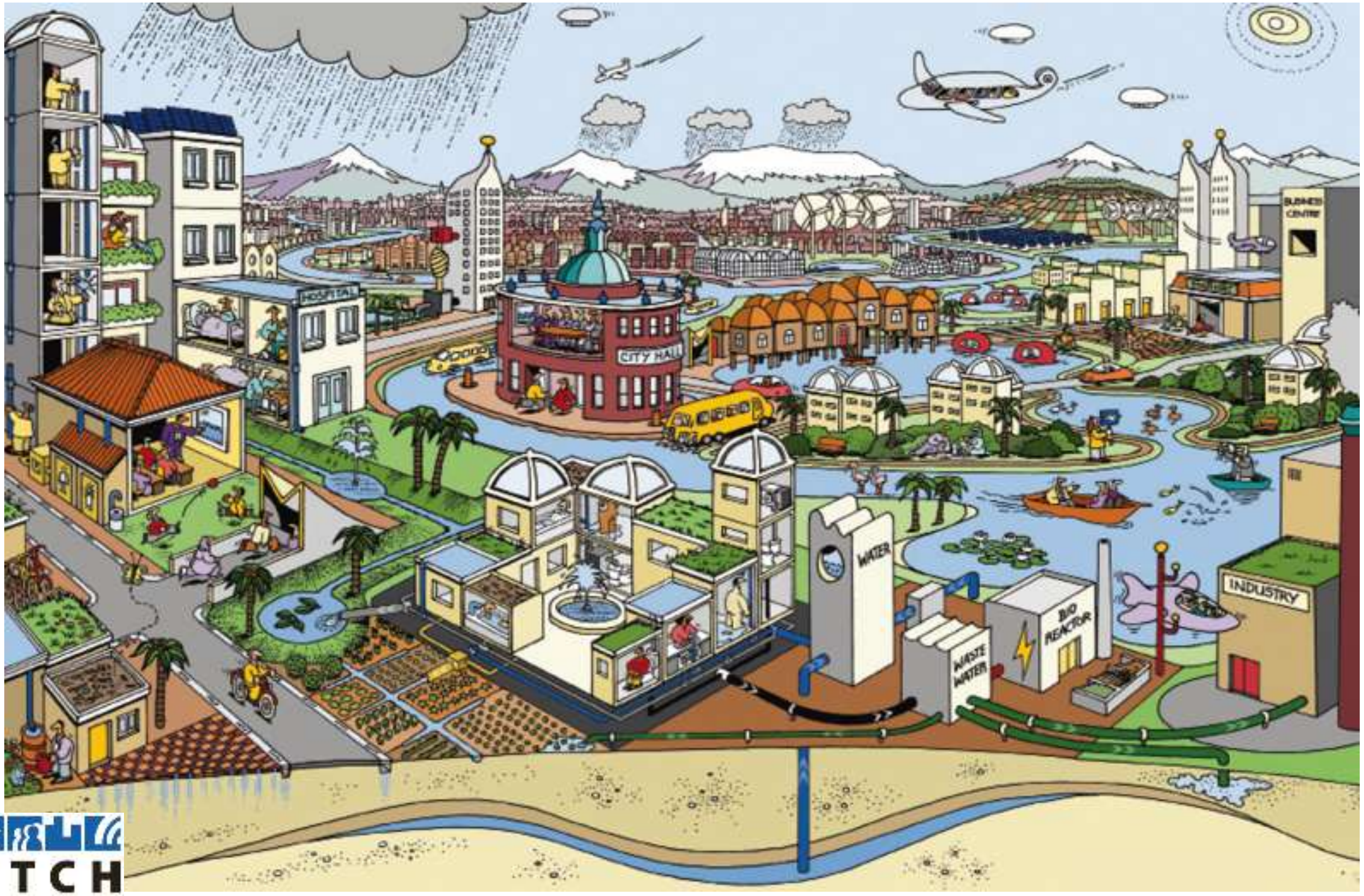
The water smart cities concept is enabled by implementing a combination of measures that are based on two strategies:

- ❖ **Restore the natural drainage capacity of cities**, by introducing nature based solutions

- ❖ **Closing the urban water cycle**, by awareness, efficiency and monitoring of measures, as well as water use.

Hattum et al., 2016.

INTEGRAL WATER MANAGEMENT FOR THE CITY OF THE FUTURE



SWITCH

www.switchurbanwater.eu

INTEGRAL WATER MANAGEMENT FOR THE CITY OF THE FUTURE

www.switchurbanwater.eu

SUDS are part of the adaptation strategy against climate change:

- **Resilience against floods**, introducing nature based solutions that reduce and attenuate flows, leaving space in current systems for possible increases of storm intensities.
- **Resilience against droughts**, encouraging on site infiltration and contributing to groundwater recharge, easing hydric stress and reducing the necessity of importing drinking water.
- **Reduce heat island effect**, increasing the greenery in urban spaces and building green roofs.
- **Decrease the energy demand in buildings**, reducing indoor temperature and providing shadow in façades.
- **Reduce the energy consumption in urban water management**, reducing the runoff quantity that enter the sewer (necessity of pumping and treating).

Transitions towards more sustainable cities:

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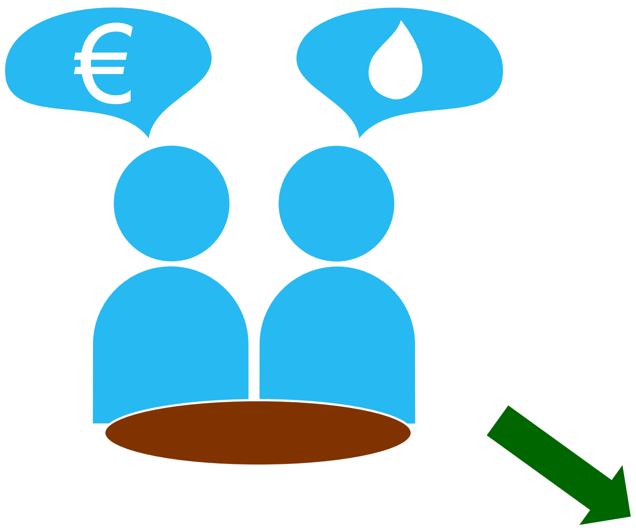
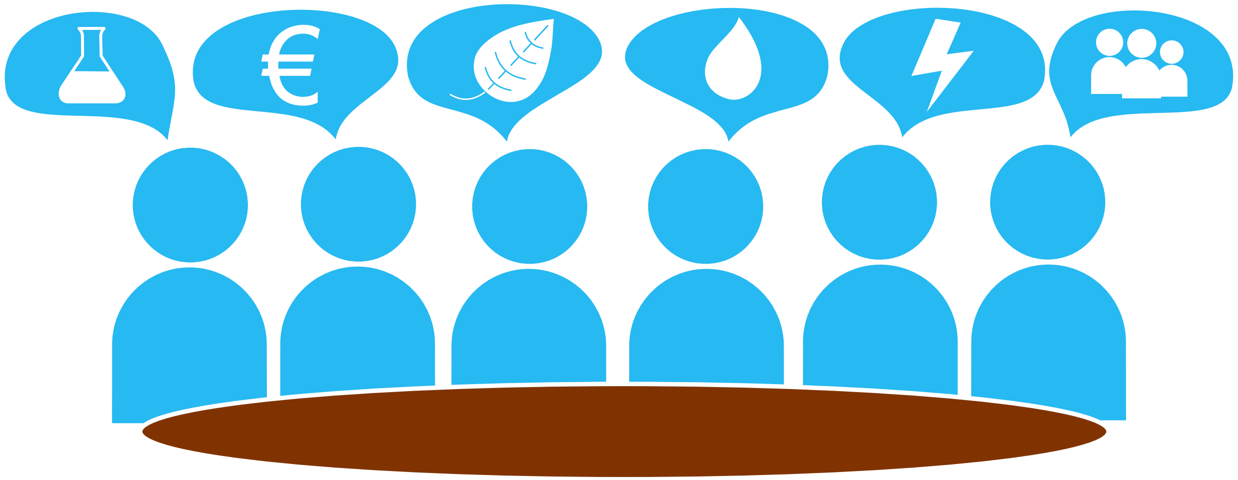




New York City (USA)

More benefits at lower economic cost

Figure 2: Phasing of Green Infrastructure and Grey Infrastructure Benefits

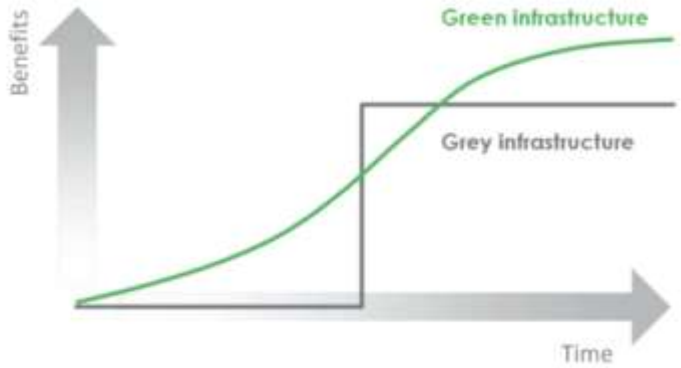
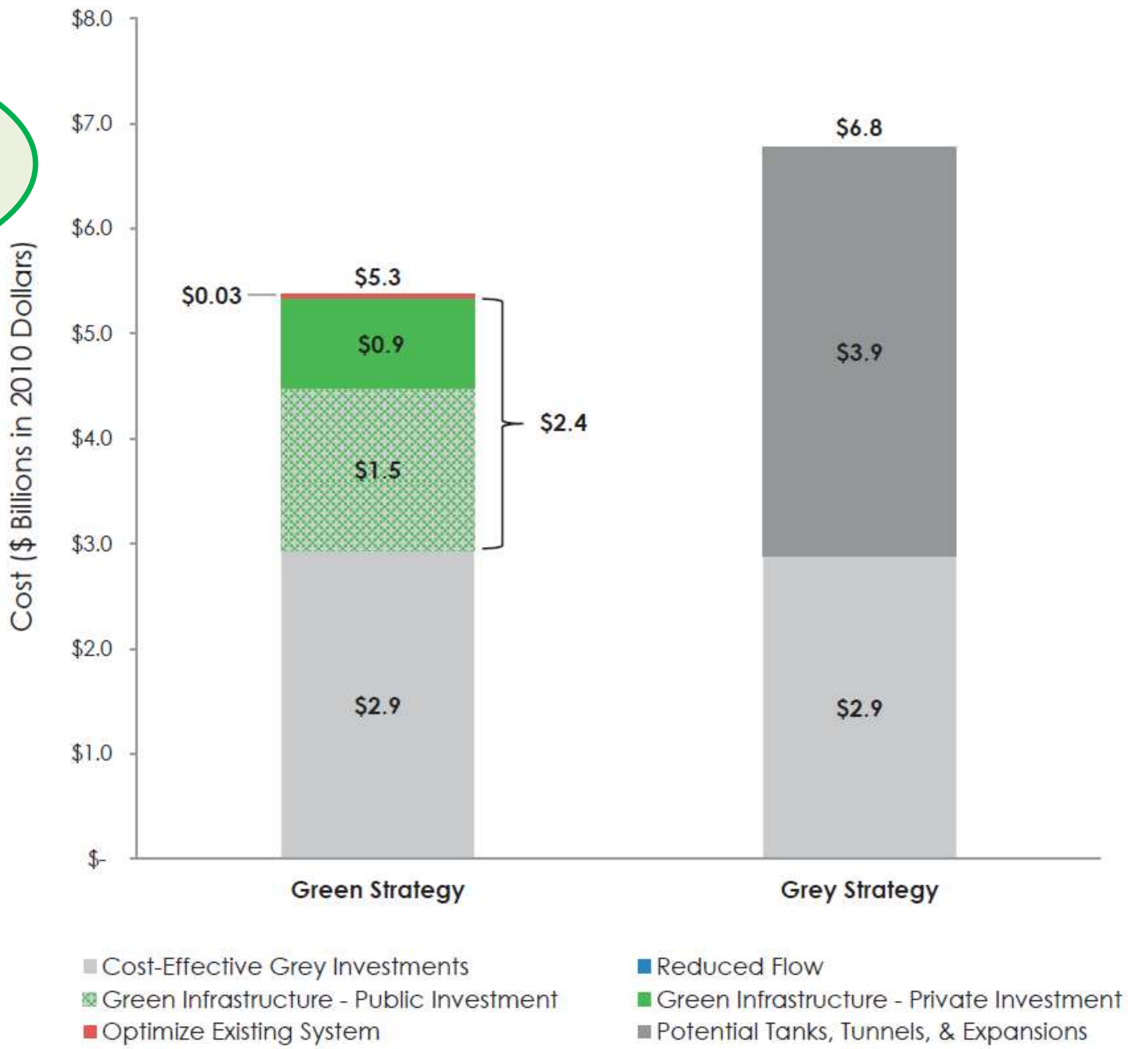


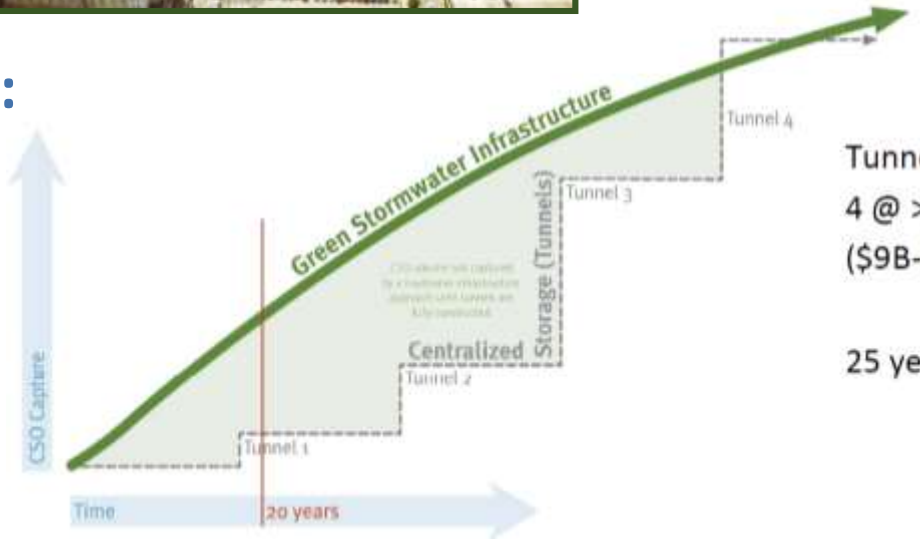
Figure 3: Citywide Costs of CSO Control Scenarios (after 20 years)



Philadelphia (USA)

Vision: “Green City, Clean Waters”.

Strategy:

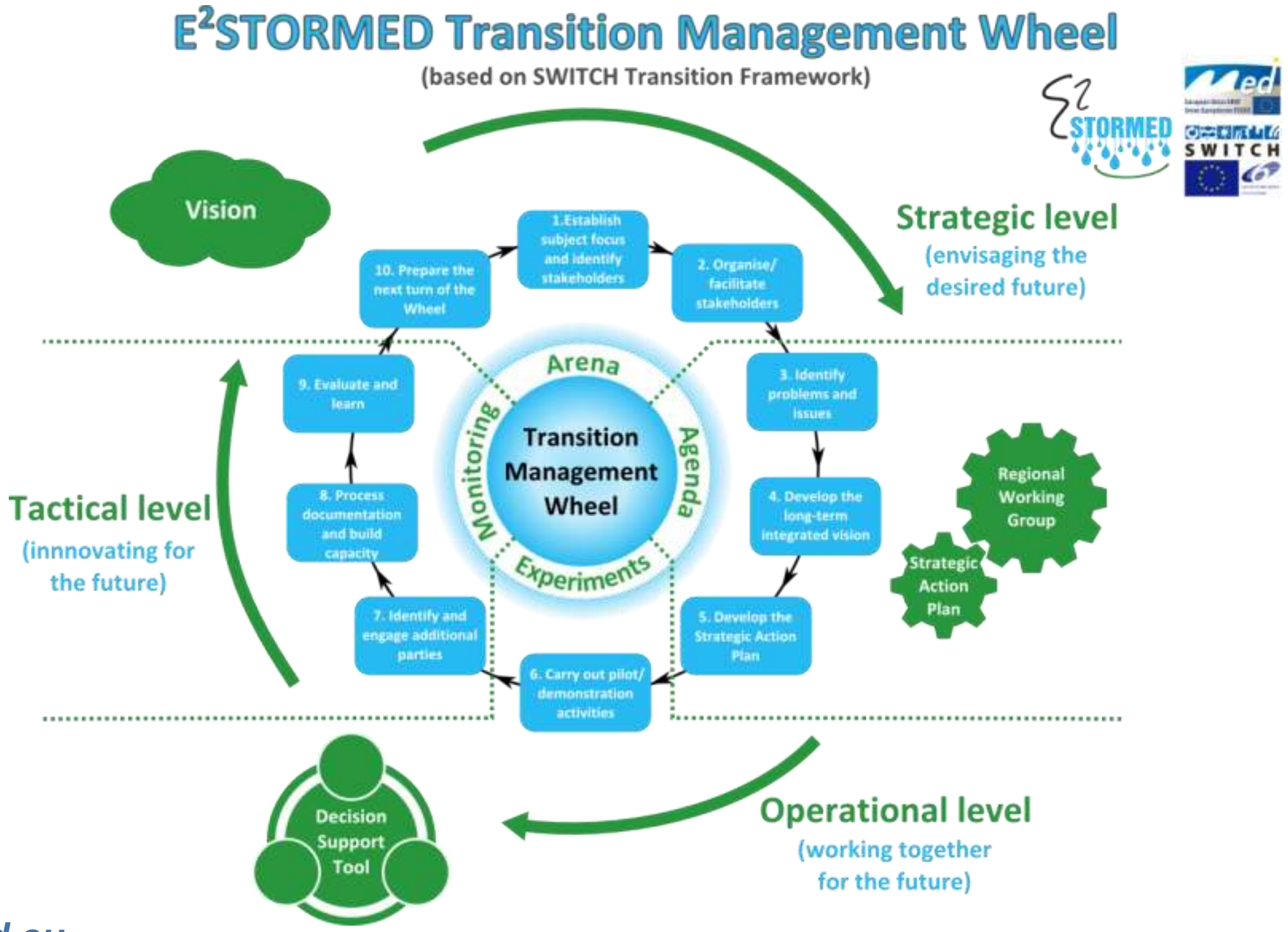


Tunnels =
4 @ >$2+B / each
($9B-10B)

25 years / each = 100 years

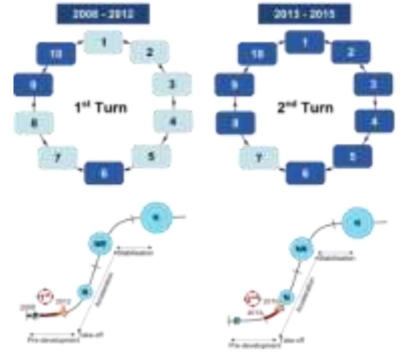
Local Jobs

Credit: Mami Hara www.phillywatersheds.org



E2STORMED Transition Management Wheel
(based on SWITCH Transition Framework)
Vision
1.Establish subject focus and identify stakeholders
2. Organise/ facilitate stakeholders
3. Identify problems and issues
4. Develop the long-term integrated vision
5. Develop the Strategic Action Plan
6. Carry out pilot/ demonstration activities
7. Identify and engage additional parties
8. Process documentation and build capacity
9. Evaluate and learn
10. Prepare the next turn of the Wheel
Arena
Agenda
Experiments
Monitoring
Transition Management Wheel
Strategic level
(envisaging the desired future)
Tactical level
(innovating for the future)
Operational level
(working together for the future)
Regional Working Group
Strategic Action Plan
Decision Support Tool

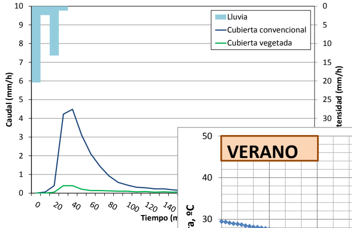
Benaguasil
AJUNTAMENT

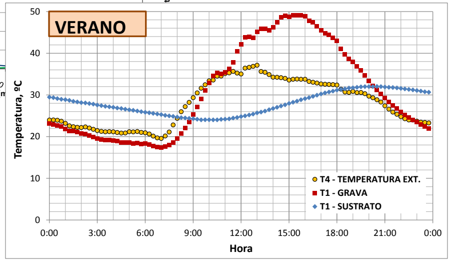


Benaguasil: Sustainable city award

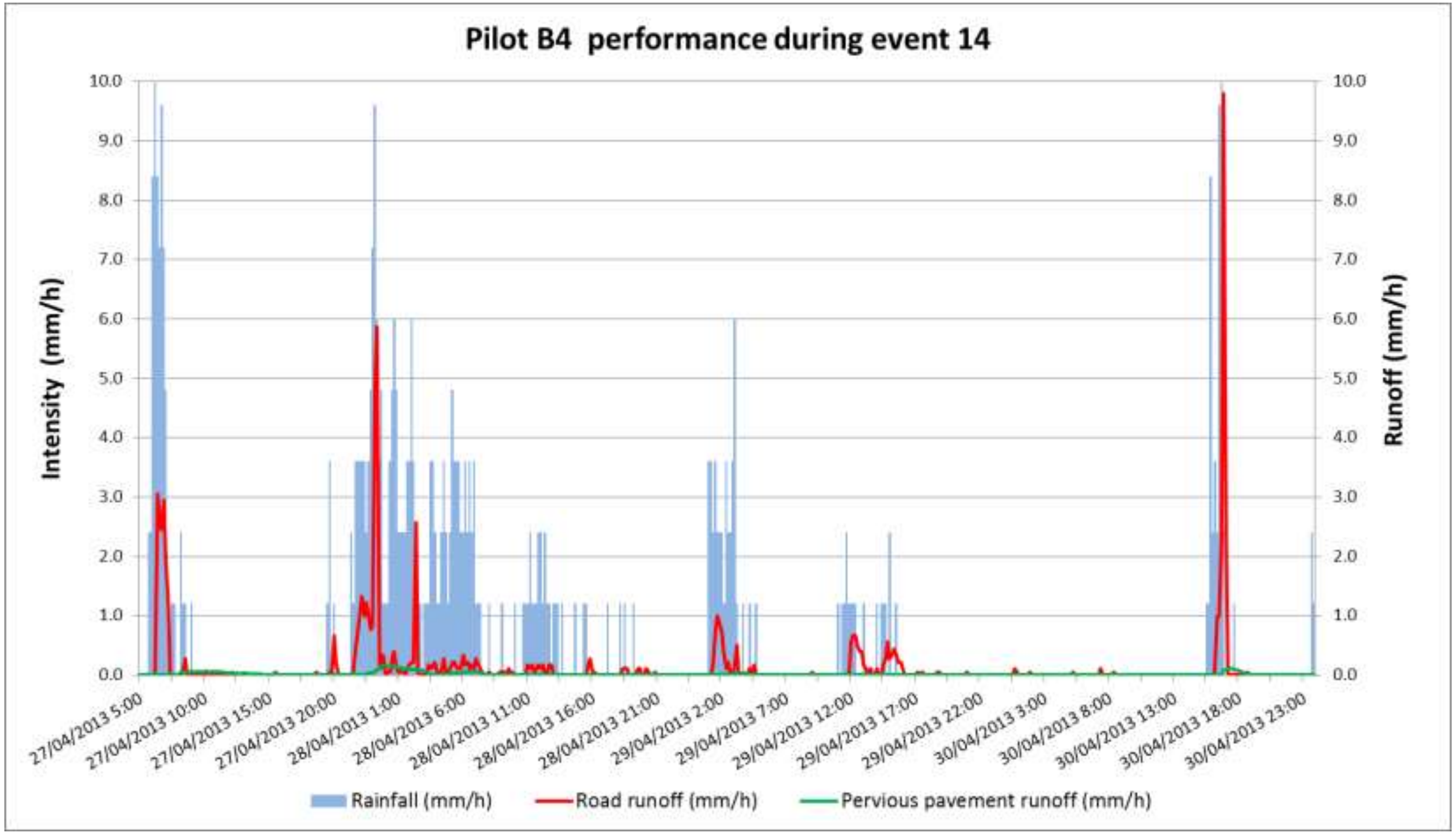
In the water management category 2015

PREMIO CIUDAD SOSTENIBLE
fundación forumambiental

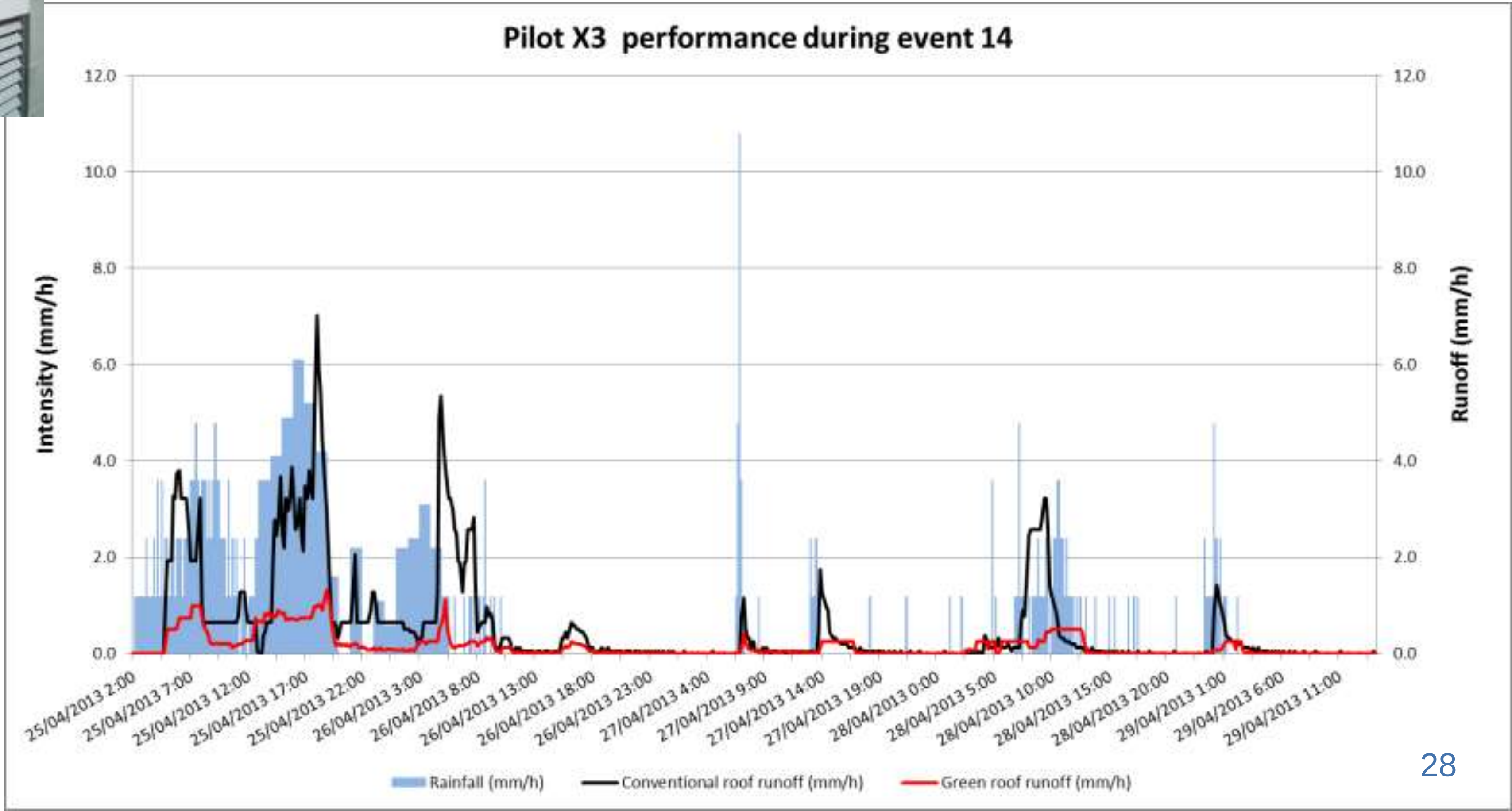




Benaguasil porous car park monitoring



Pilot SUDS experience in Gozalbes Vera Public School. Xàtiva (Valencia).



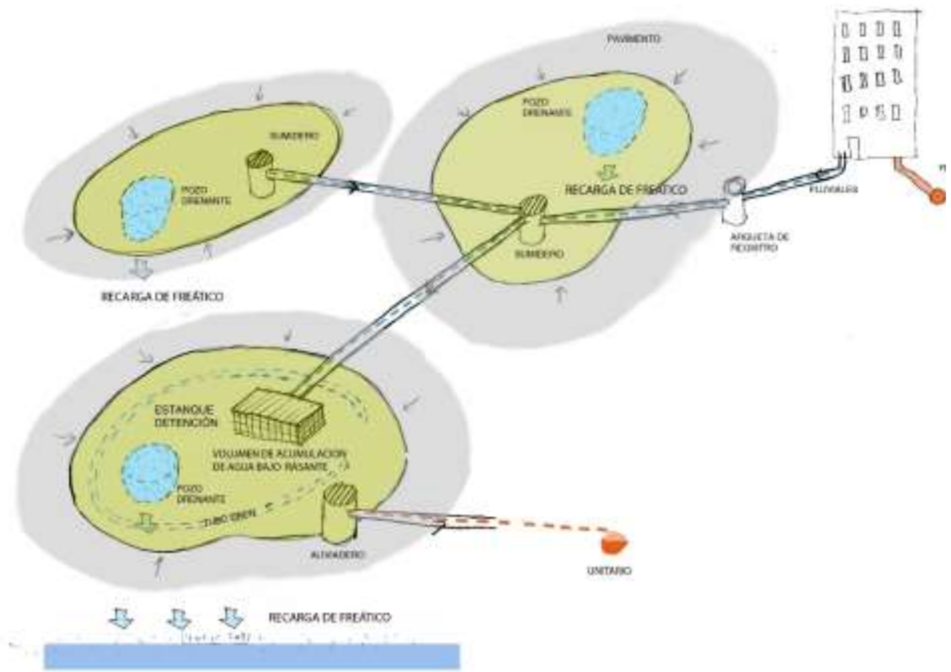
Urban Development Works Plan in the new BBVA offices, Madrid.

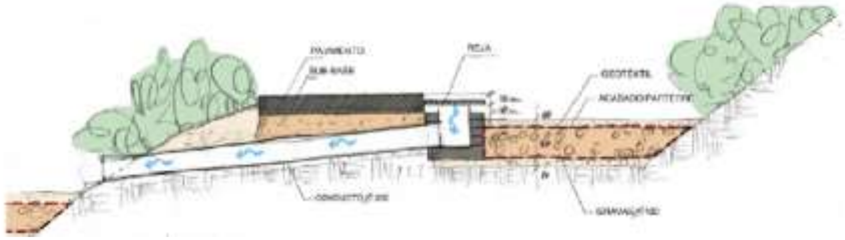
MADRID

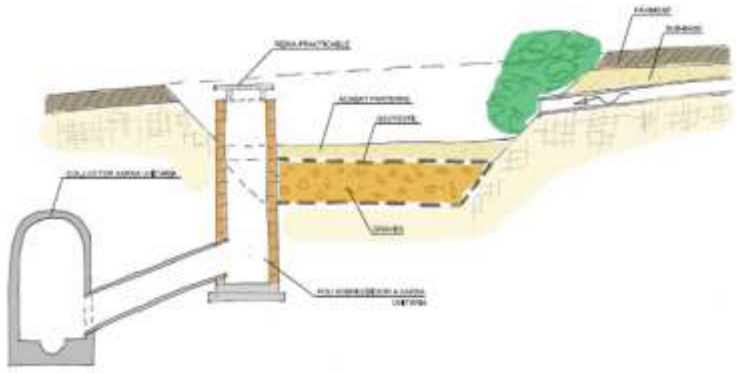
Wanda Metropolitano Stadium site development, Madrid.

MADRID

Urban development project in the area around the social housing in the Can Cortada neighbourhood, Barcelona.







Ajuntament de Barcelona

Urban development project in the area around the social housing in the Can Cortada neighbourhood, Barcelona.





Ajuntament de Barcelona

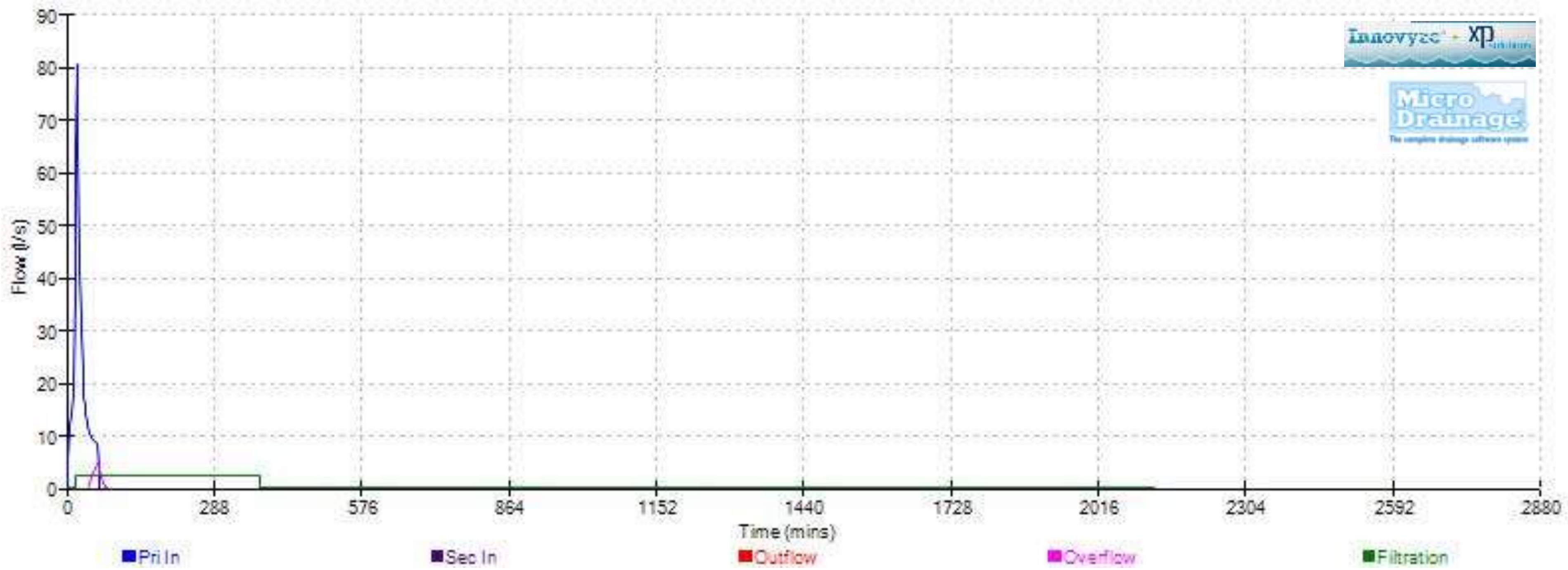
Urban development of the Bon Pastor Neighbourhood, Barcelona.

Urban development of the Bon Pastor Neighbourhood, Barcelona.

Result for the hydrologic-hydraulic modelling for the design storm

T = 10 years
Duration = 1 hour
Maximum intensity = 212 mm/h
Total rainfall volumen = 59 mm

Reduction of peak inflow to the combined sewer in **85%** approx.

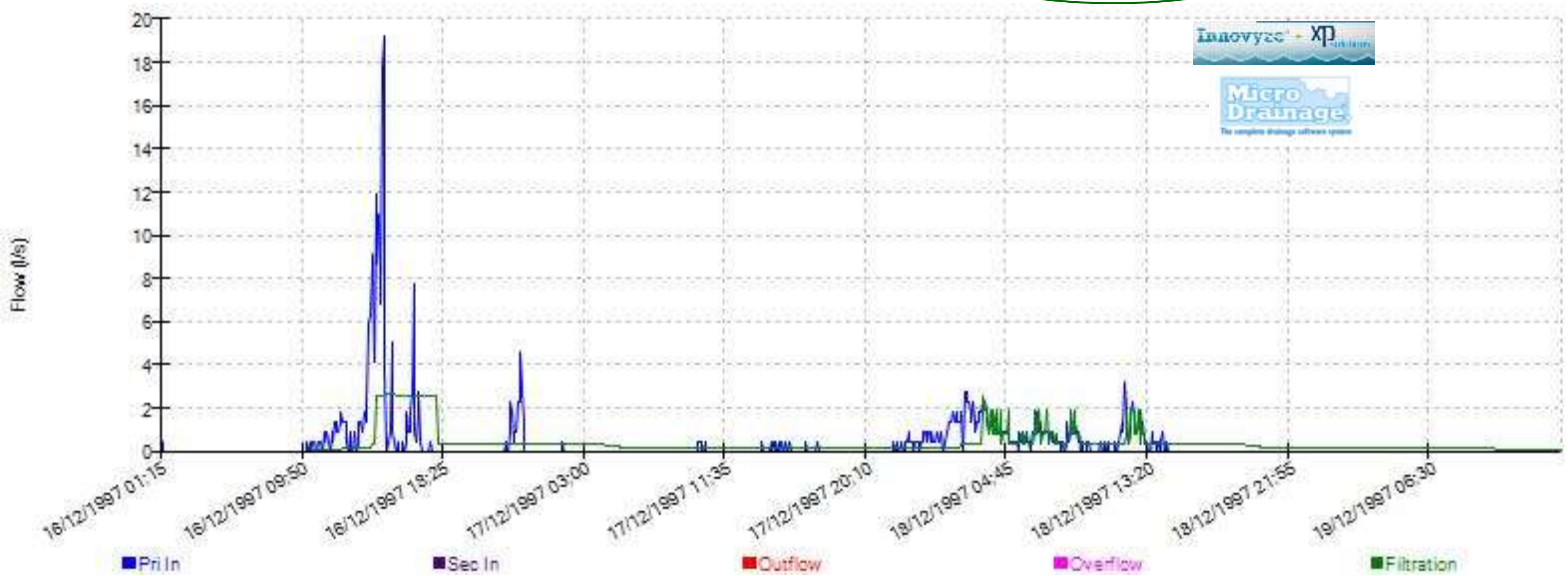


Urban development of the Bon Pastor Neighbourhood, Barcelona.

Result for the hydrologic-hydraulic modelling for the typical year: 1997

Year 1997
5 minute precipitation data
Total rainfall volumen = 478 mm

Reduction of volume to enter in the combined sewer in 99,9 % approx.



SUDS in El Greco Avenue (Healthy City), Sevilla.

Vegetated swale along the Xàtiva North Ring Road (Valencia).

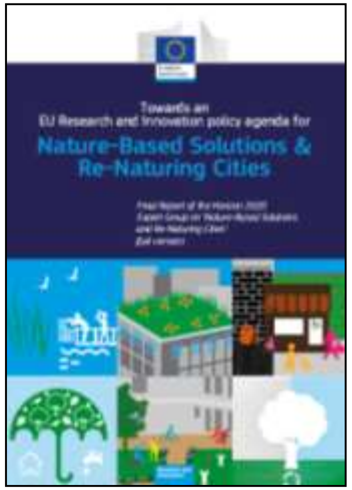
CoSuDS: Collaborative transition towards sustainable urban drainage: making it happen at district scale.

- The main goal of this european project was to **promote the transition toward a more efficient and sustainable stormwater management in cities**.
- **Collaborative sessions** with the participation of more than 30 **stakeholders** associated with water management in city, regional or national scale.

CoSuDS
COLLABORATIVE TRANSITION TOWARDS SUSTAINABLE URBAN DRAINAGE: MAKING IT HAPPEN AT DISTRICT SCALE

Specific training in runoff management using SUDS.

RedSUDS workshop 2017 and 2019



Spanish framework: RD 638/2016 de modificación del RDPH

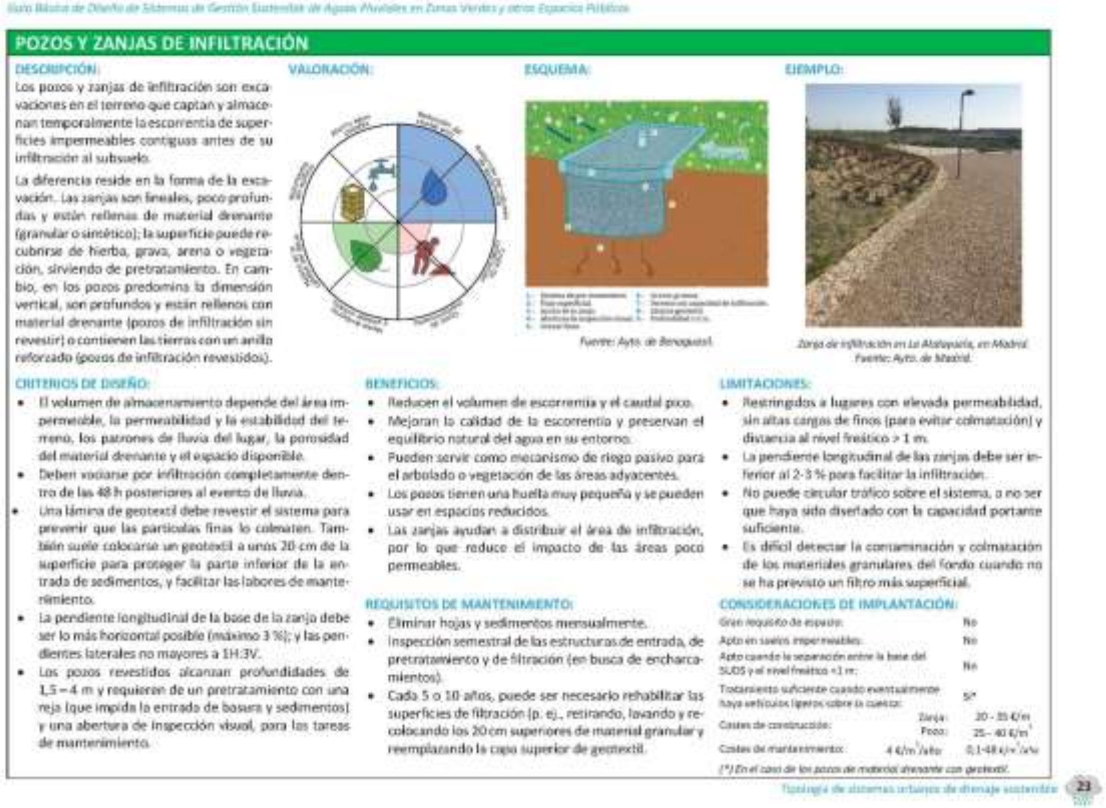
Trece. Se añade un artículo 126 ter en la sección 5.ª del capítulo III del título II con la siguiente redacción:

«Artículo 126 ter. *Criterios de diseño y conservación para obras de protección, modificaciones en los cauces y obras de paso.*

Además del cumplimiento de los requisitos previstos en los dos artículos anteriores con carácter general, se establecen los siguientes criterios para el diseño de las actuaciones en dominio público hidráulico:

7. Las nuevas urbanizaciones, polígonos industriales y desarrollos urbanísticos en general, deberán introducir sistemas de drenaje sostenible, tales como superficies y acabados permeables, de forma que el eventual incremento del riesgo de inundación se mitigue. A tal efecto, el expediente del desarrollo urbanístico deberá incluir un estudio hidrológico-hidráulico que lo justifique.»

Basic guide to designing sustainable rainwater management systems in green areas and other public spaces. Madrid City Council.



Guía Básica de Diseño de Sistemas de Gestión Sostenible de Aguas Pluviales en Zonas Verdes y otros Espacios Públicos

POZOS Y ZANJAS DE INFILTRACIÓN

DESCRIPCIÓN:

Los pozos y zanjas de infiltración son excavaciones en el terreno que captan y almacenan temporalmente la escorrentía de superficies impermeables contiguas antes de su infiltración al subsuelo.

La diferencia reside en la forma de la excavación. Las zanjas son lineales, poco profundas y están rellenas de material drenante (granular o sintético); la superficie puede recubrirse de hierba, grava, arena o vegetación, sirviendo de pretratamiento. En cambio, en los pozos predomina la dimensión vertical, son profundos y están rellenos con material drenante (pozos de infiltración sin revestir) o contienen las tierras con un anillo reforzado (pozos de infiltración revestidos).

VALORACIÓN:

ESQUEMA:

Fuente: Ayto. de Benaguasil.

EJEMPLO:

Zanja de infiltración en La Atalayuela, en Madrid. Fuente: Ayto. de Madrid.

CRITERIOS DE DISEÑO:

- El volumen de almacenamiento depende del área impermeable, la permeabilidad y la estabilidad del terreno, los patrones de lluvia del lugar, la porosidad del material drenante y el espacio disponible.
- Deben vaciarse por infiltración completamente dentro de las 48 h posteriores al evento de lluvia.
- Una lámina de geotextil debe revestir el sistema para prevenir que las partículas finas lo colmaten. También suele colocarse un geotextil a unos 20 cm de la superficie para proteger la parte inferior de la entrada de sedimentos, y facilitar las labores de mantenimiento.
- La pendiente longitudinal de la base de la zanja debe ser lo más horizontal posible (máximo 3 %); y las pendientes laterales no mayores a 1H:3V.
- Los pozos revestidos alcanzan profundidades de 1,5 – 4 m y requieren de un pretratamiento con una reja (que impida la entrada de basura y sedimentos) y una abertura de inspección visual, para las tareas de mantenimiento.

BENEFICIOS:

- Reducen el volumen de escorrentía y el caudal pico.
- Mejoran la calidad de la escorrentía y preservan el equilibrio natural del agua en su entorno.
- Pueden servir como mecanismo de riego pasivo para el arbolado o vegetación de las áreas adyacentes.
- Los pozos tienen una huella muy pequeña y se pueden usar en espacios reducidos.
- Las zanjas ayudan a distribuir el área de infiltración, por lo que reduce el impacto de las áreas poco permeables.

REQUISITOS DE MANTENIMIENTO:

- Eliminar hojas y sedimentos mensualmente.
- Inspección semestral de las estructuras de entrada, de pretratamiento y de filtración (en busca de encharcamientos).
- Cada 5 o 10 años, puede ser necesario rehabilitar las superficies de filtración (p. ej., retirando, lavando y recolocando los 20 cm superiores de material granular y reemplazando la capa superior de geotextil.

LIMITACIONES:

- Restringidos a lugares con elevada permeabilidad, sin altas cargas de finos (para evitar colmatación) y distancia al nivel freático > 1 m.
- La pendiente longitudinal de las zanjas debe ser inferior al 2-3 % para facilitar la infiltración.
- No puede circular tráfico sobre el sistema, a no ser que haya sido diseñado con la capacidad portante suficiente.
- Es difícil detectar la contaminación y colmatación de los materiales granulares del fondo cuando no se ha previsto un filtro más superficial.

CONSIDERACIONES DE IMPLANTACIÓN:

Gran requisito de espacio:		No
Apto en suelos impermeables:		No
Apto cuando la separación entre la base del SUDS y el nivel freático <1 m:		No
Tratamiento suficiente cuando eventualmente haya vehículos ligeros sobre la cuenca:		Sí*
Costes de construcción:	Zanja:	20 - 35 €/m
	Pozo:	25 – 40 €/m³
Costes de mantenimiento:	4 €/m³/año	0,1-48 €/m³/año

(*) En el caso de los pozos de material drenante con geotextil.

Tipología de sistemas urbanos de drenaje sostenible 23

Sustainable drainage grids

Conclusions

- Communities **cannot afford to wait** to address the flooding and public health hazards of stormwater: the curb and gutter (gray infrastructure) approach alone to managing stormwater is **not enough** to address these risks.
- In the past several years, many cities have found that an **effective**, **comprehensive**, **long-term approach** to managing stormwater includes **green infrastructure** practices that manage rain **where it falls**.
- Comprehensive, long-term planning for stormwater management - **integrating stormwater** with economic development, transportation, recreation and other planning - supports smart investments and new funding sources.
- Communities are finding the **benefits** from such long-term approaches go well beyond helping to meet regulatory requirements and turn hazards into **opportunities** for their communities.

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THANK YOU !

Sara.Perales@GreenBlueManagement.com