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Surface water runoff - the overlooked threat?

Bridget Woods Ballard

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Aim

- To take a look at surface water runoff quality and set the risk it poses in context

  (current UKWIR project: costs, carbon, water quality benefits, modelling approaches… Stantec lead, due for publication early next year)

- To consider how SuDS could help mitigate the risk
- To consider some approaches and research from Europe

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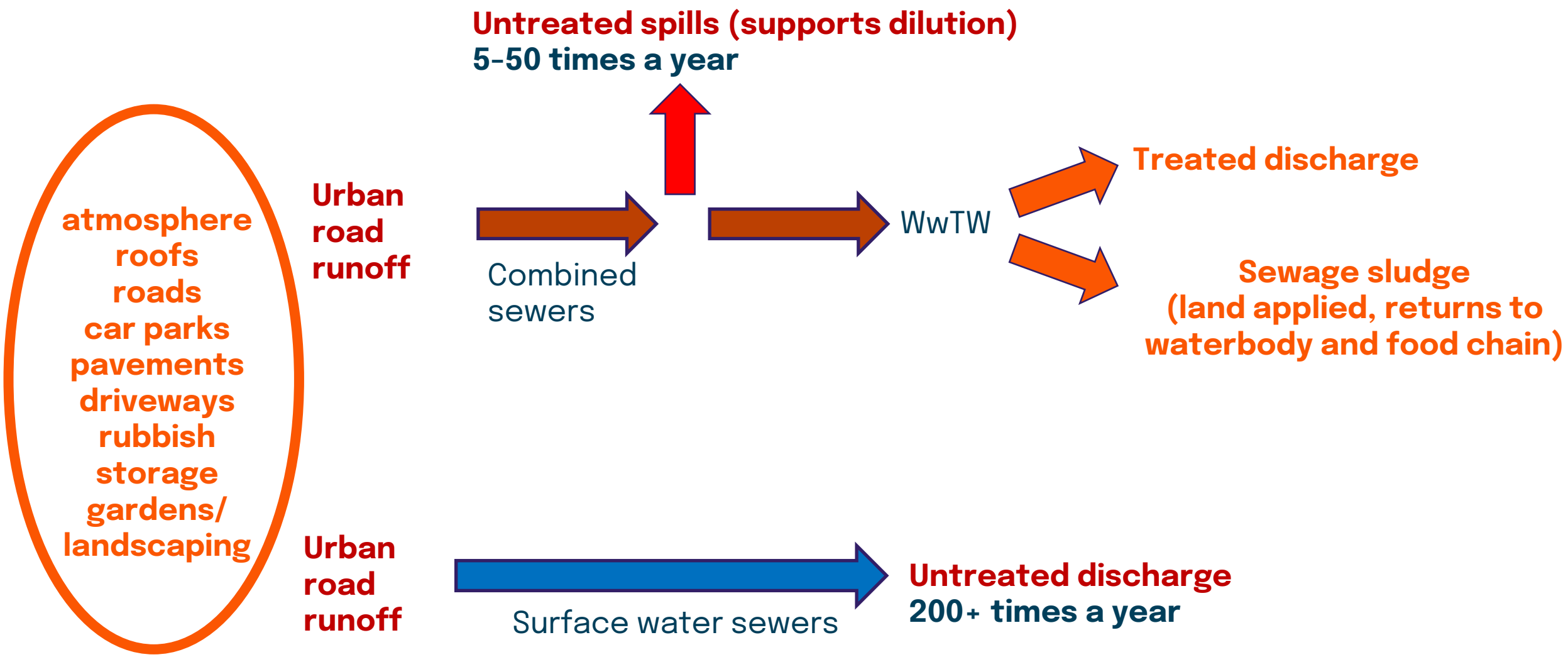

CURRENT NORMAL

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Regulatory/ policy drivers

- WFD stated objectives include:
  - To prevent deterioration of, and protect/enhance/restore waterbody status
  - To progressively reduce pollution from priority substances and priority hazardous substances

    & to reduce pollutant levels to meet Env Qual Standards
- UWWTD The European Commission tabled its proposal to revise the UWWTD on 26 October 2022, as part of 'a zero-pollution legislative package'. The proposals include a requirement for:

  locally integrated urban wastewater management plans should be established to combat pollution from rain waters (urban runoff and CSOs)
- GBR10 Scotland – Water Environment (Controlled Activities) (Scotland) Regulations 2011. General Binding Rule 10 requires all development to be:

  'drained by a SuD system or equivalent system equipped to avoid pollution of the water environment'

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Regulatory/ policy drivers (continued)

- **Schedule 3 Wales** – Schedule 3 of the Flood & Water Management Act, implemented in January 2019 includes a statutory SuDS standard (S3) for water quality management:

  Treatment for surface water runoff should be provided to prevent negative impacts on the receiving water quality and/or protect downstream systems…'

- **Nothing? England** – no current requirement to mitigate water quality impacts from urban runoff

  Schedule 3 of Flood & Water Management Act (with similar water quality standards to Wales?) expected within 12 months (?)

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Urban runoff pollutants

atmosphere
roofs
roads
car parks
pavements
driveways
rubbish
storage
gardens/ landscaping

- Solids
- Heavy metals
- Biodegradable organic matter (COD/BOD)
- Organic micropollutants (e.g. hydrocarbons, PAHs, PCBs, fire retardants, insecticides etc)
- Pathogenic microorganisms (e.g. E-coli)
- Nutrients (nitrogen, phosphorus)
- Microplastics

Note: the chemical 'cocktail' effect is also of concern

1. Short-term impacts
2. Long-term impacts
3. Physical impacts

Currently
'prevents 18% of water bodies from achieving good ecological status' (Defra, 2021)

What influences the 'numbers'?

- Current (and historic) land use activities e.g. residential roofs/metal commercial roofing; vehicle parking, roads, highways, industrial use
- Nature of the runoff surfaces (permeability, texture, depth)
- Intensity of storm, frequency of storms, weather condition between storms
- Drainage system characteristics (e.g. pipes and gullies can act as sources and sinks, depending on the event; in-sewer deposition, erosion, bio-degradation)
- Variability of biological and physico-chemical characteristics of pollutants themselves
- Uncertainty in sampling and chemical analyses

We need studies that aggregate lots of data or very well-established databases e.g. US National Stormwater Quality Database

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Solids (TSS)

- Sources: soil erosion, dust, litter, human activity, atmospheric deposition, construction activities
- Smothers habitat and aquatic life, limits light penetration and vegetation growth
- Associated with toxic pollutants that adsorb to its surfaces.
- Median urban runoff EMCs generally: 50-250 mg/l (but can be magnitudes higher):
  - Urban runoff similar to CSO concentrations
  - Untreated wastewater 100-350 mg/l
  - Treated wastewater: around 20 mg/l
  - EQSs: 10-30 mg/l
  - SuDS normally focussed on TSS capture: bioretention effluent concentrations: 4-10 mg/l

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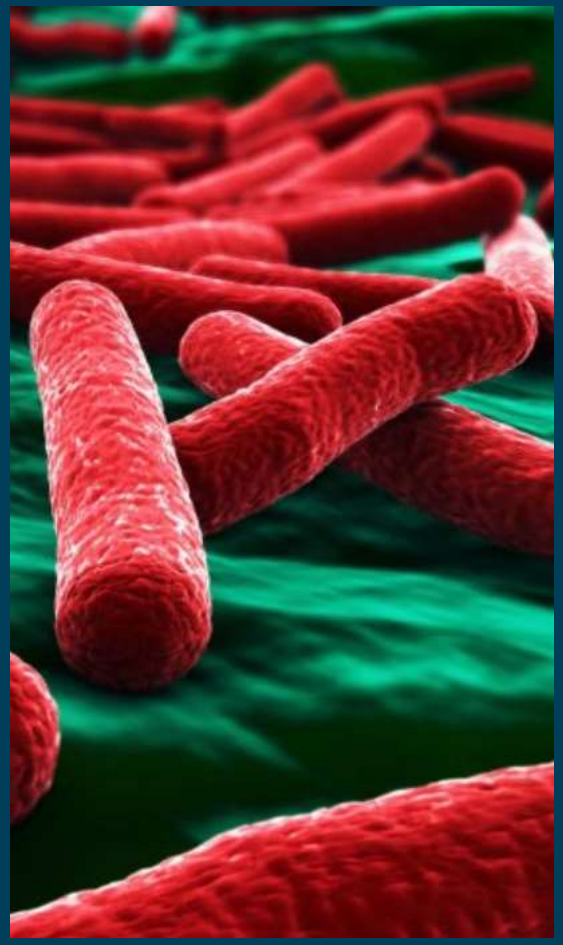
Public health contaminants



- Bacteria and disease-causing organisms from pet and bird faeces, rubbish and waste management facilities, decaying litter and plant matter, and misconnections
- Faecal coliform levels vary widely e.g. 2000-90,000/100 ml but possibly up to 2 OoM greater
  - Recreational standards < 500 / 100 ml
  - CSOs will have higher bacteria concentrations, untreated wastewater significantly higher
  - Treated wastewater will have very low concentrations
  - SuDS effluent concentrations highly variable, unlikely to reduce consistently to level of standards.
    Open SuDS can be exporters

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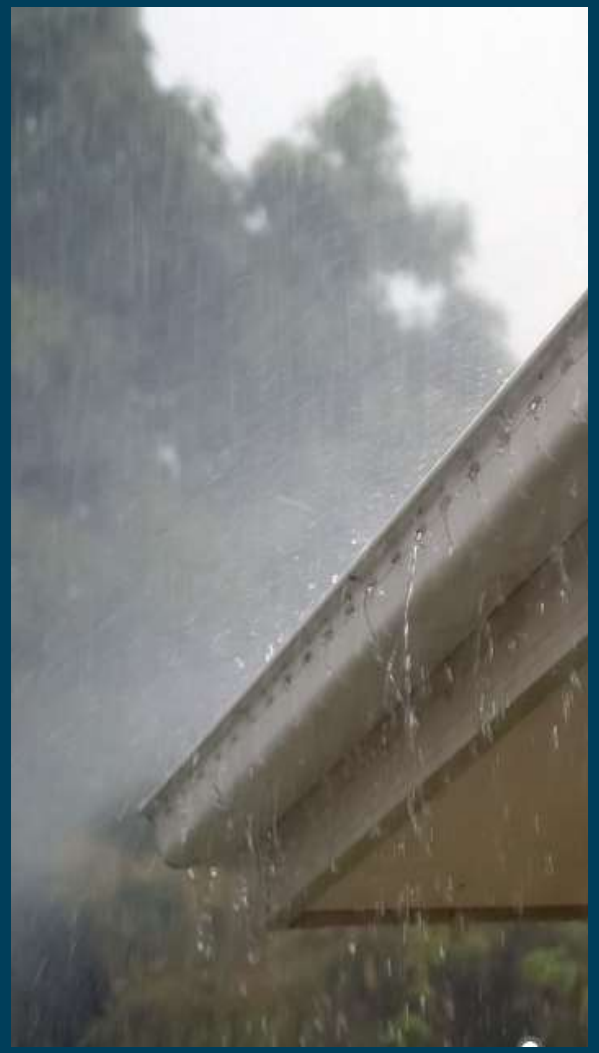
Nutrients

- Causes eutrophication, algal blooms, species imbalances, public health threats and general decline in waterbody quality
- Sources: fertilisers, animal waste, misconnections, sediments, engine lubricants, corrosion inhibitors, atmospheric deposition
- Total P EMCs:
  - Similar to recommended standards
  - Leaf litter and high P compost are significant contributors
  - SuDS only effective if routinely maintained
- Total N EMCs:
  - Individual N compound contributions unlikely to be critical apart from unionised ammonia
  - Significant sectoral contribution to N loadings in waterbodies
  - Misconnections may require dilution factors > 100:1
  - Consistent removal in SuDS is complex and challenging

Heavy metals



- Derive mainly from vehicles and building materials / roofing
- Toxic to soil and plant health, bio-accumulated by fish and invertebrates
- Often adsorbed to sediments but can be dissolved
- Recent studies aggregating large numbers of datasets suggests Cu, Zn and Pb EMCs are likely to be > than 100 x EQSs
- Urban runoff likely to have similar or higher heavy metal concentrations to treated wastewater
- SuDS designed for sediment removal, sorption and precipitation can effectively reduce concentrations to safe levels

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Petroleum Hydrocarbons

- Exhaust emissions, vehicle leaking, oil storage tanks, improper disposal of waste oil,
- Oil and grease, VOCs and PAHs (more immobile, more persistent, more toxic, higher bioaccumulation rates, carcinogenic, alter ecosystems)
- Concentrations tend to be correlated with amount of traffic
- Fluoranthene and Benzo(A)pyrene (linked to engine combustion) are of particular concern
- PAH concentrations in urban runoff likely to > treated wastewater and CSO effluent streams, requiring > 100 x dilution for acceptable toxicity levels.
- Sediment removal prior to capture in permanent water bodies is crucial; capture and degradation of PAHs is most effective in components that dry between events

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Synthetic Organic Compounds

- Manufactured compounds including pesticides, insecticides, solvents, household and industrial chemicals
- Even low concentrations of regular discharges are highly toxic
- Pesticide concentrations may be higher in urban areas than agricultural areas
- Misconnections mean domestic pharmaceuticals also found
- PFOA and PFOS (forever chemicals – stain/grease/water repellent materials, wrappers, shampoos…) concentrations likely to be 2-3 OoM > EQSs
- Likely to be higher concentrations in CSOs and wastewater effluents (WWTPs don't remove these contaminants effectively)
- UKWIR (2022) suggests wetlands may be effective at removing PFOS but data very limited

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Microplastics

- Tyres, brakes, road marking materials, roof and building material ‘coatings’, roof membranes, PVC gutters, degraded litter, plastic pellets, microbeads… tyre derived microplastics including rubber core, plus additives, plus attached brake-abrasion particles
- Impacts and relative toxicity poorly understood
- Large surface areas which act as carriers of other pollutants (in particular, persistent organic pollutants)
- Road runoff likely to contribute 40% of microplastics found in the water environment
- Initial findings indicate SuDS very effective at removal (depending on particle density) but efficacy rates may reduce through time and sinks could become sources

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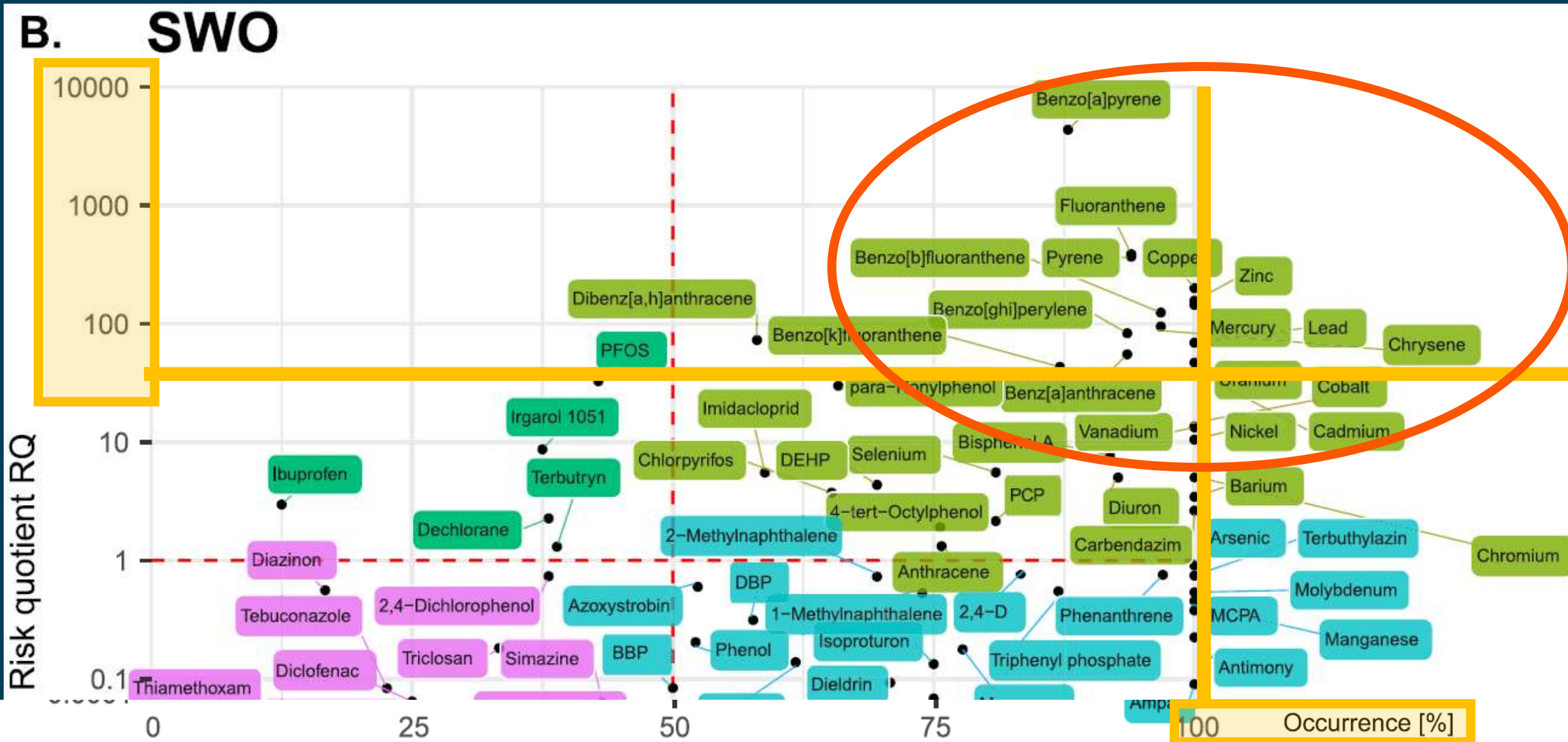
Direct surface water discharges (10 years of micropollutant monitoring (NB excludes bacteria, nutrients) : Mutzner et al, 2022)



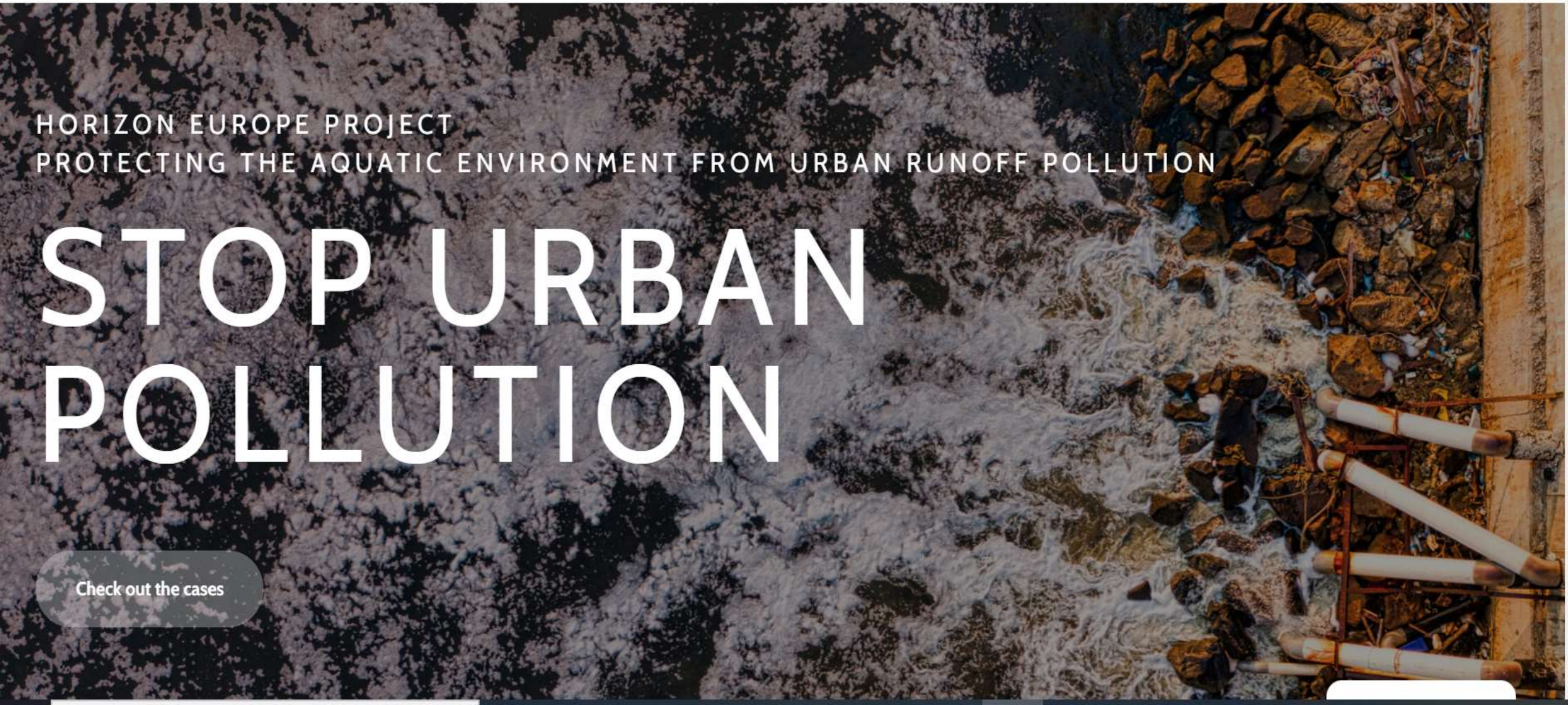
What is happening elsewhere in Europe?

- Germany has new regulations specifying treatment levels of stormwater prior to discharge to surface and groundwaters (2020)
- Copenhagen… road runoff is all treated

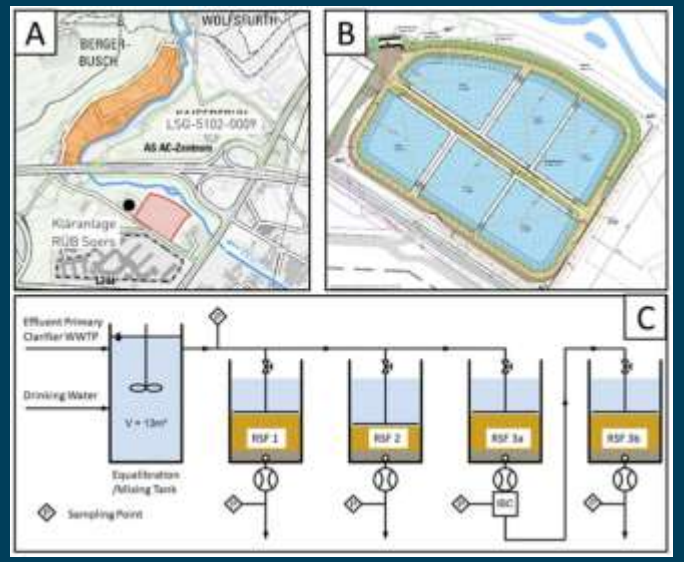
Surface systems - treated in roadside swales

Surface system – treated in biofiltration systems

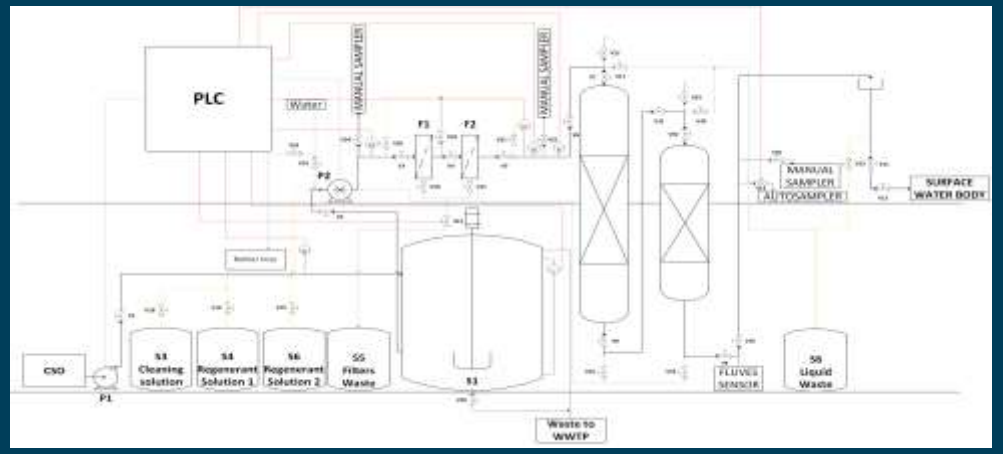
Combined systems - treated n WWTW and when flows exceed a threshold, in-sewer diverters re-direct water to surface (or sub-surface) storage


HORIZON EUROPE PROJECT
PROTECTING THE AQUATIC ENVIRONMENT FROM URBAN RUNOFF POLLUTION
STOP URBAN POLLUTION
Check out the cases

Germany: full scale retention soil filter for CSO treatment



Italy: pilot plant for removing suspended solids, COD, N, P, metals and PFAS, based on adsorption and microfiltration

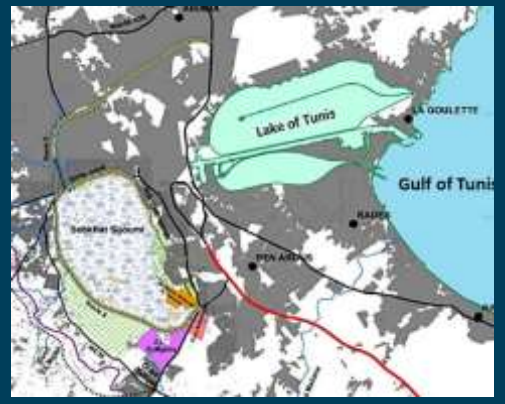


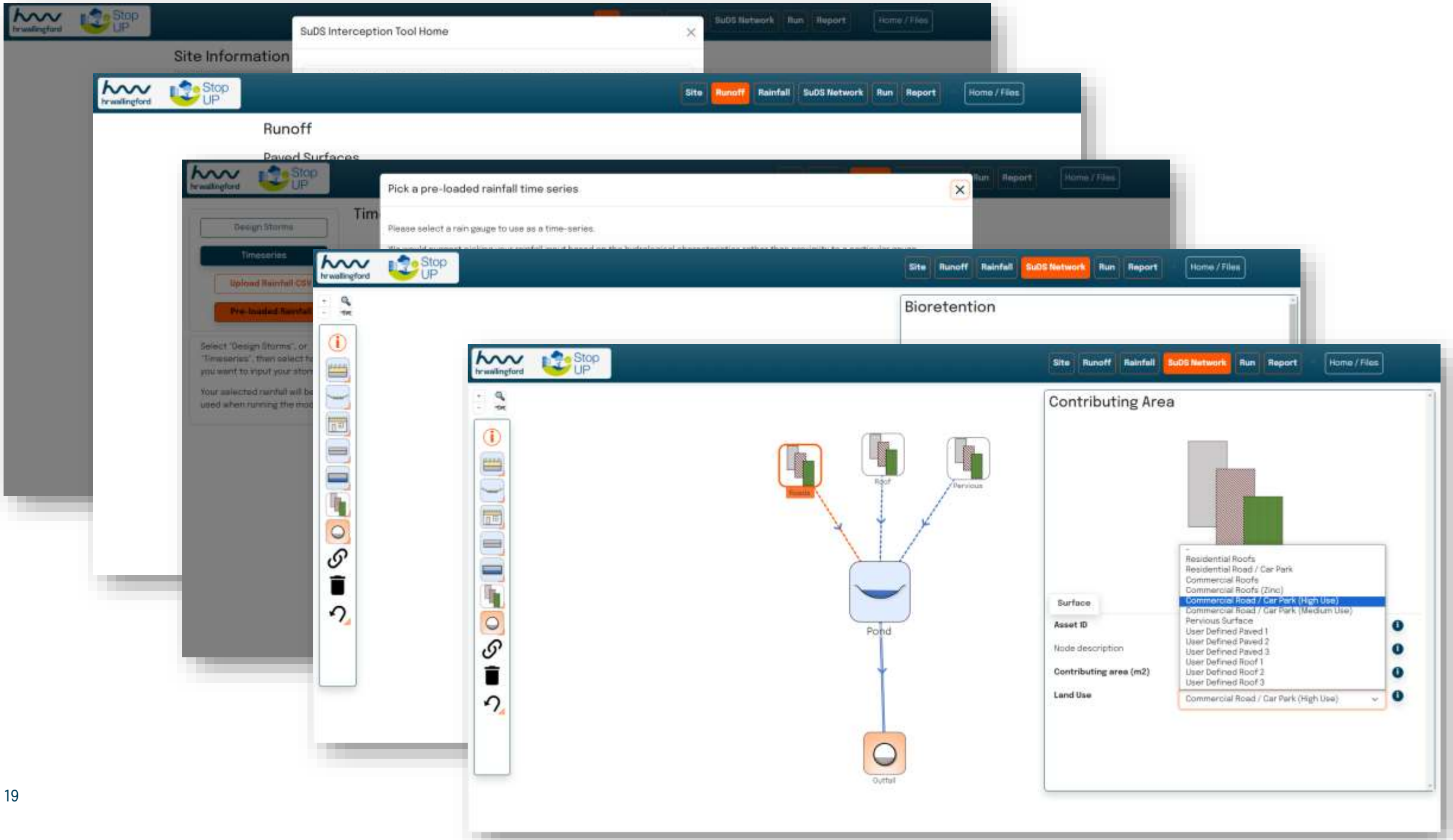
Switzerland: use of rainfall radar and active system control

Belgium: large-scale treatment and disconnection of highway runoff using swales, filter systems and infiltration

Norway: Impact of retrofit bioretention on CSO spill performance

Tunisia: The treatment of stormwater and CSO volumes using hybrid filtration (with bespoke flocculants) and constructed wetland technologies

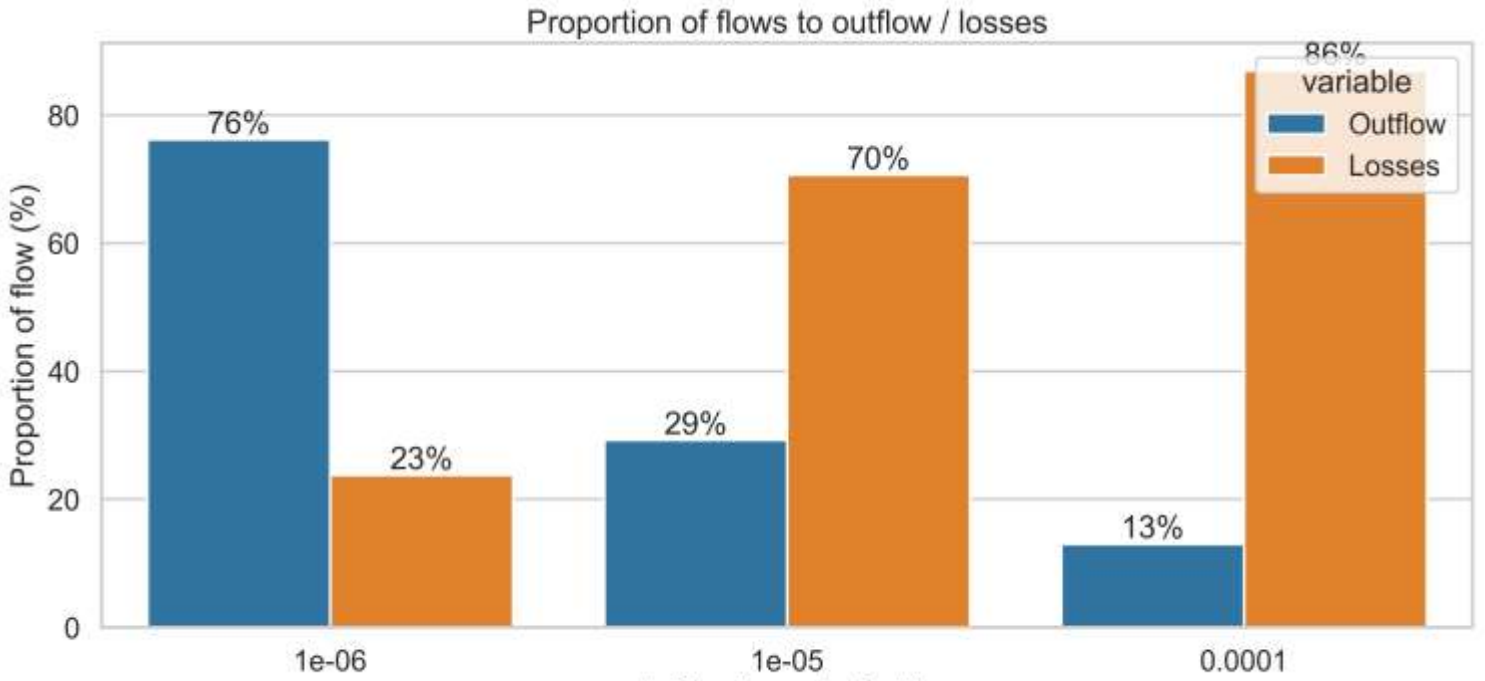


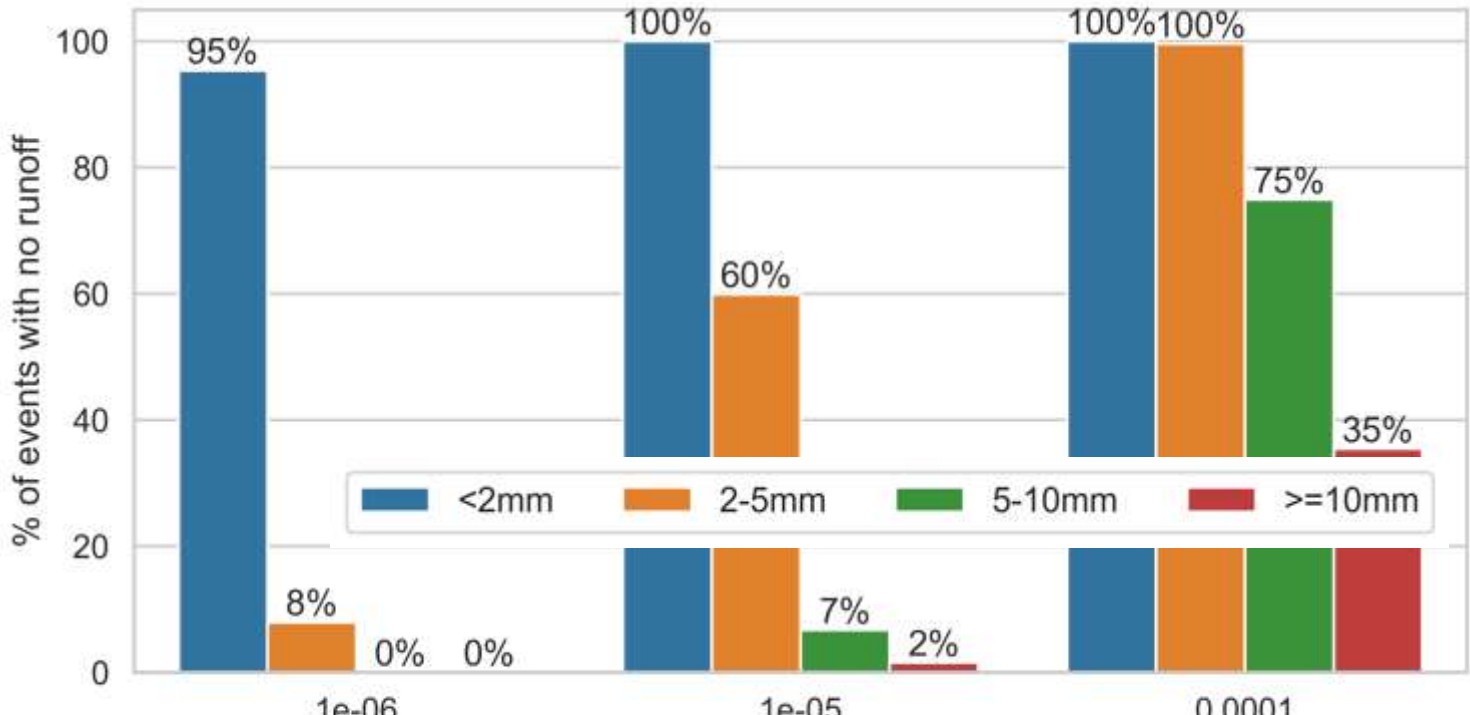

SuDS Interception Tool Home
Site Information
Site
Runoff
Rainfall
SuDS Network
Run
Report
Home / Files
Runoff
Paved Surfaces
Pick a pre-loaded rainfall time series
Please select a rain gauge to use as a time-series.
Design Storms
Timeseries
Bioretention
Roof
Pervious
Pond
Outfall
Contributing Area
Residential Roofs
Residential Road / Car Park
Commercial Roofs
Commercial Roofs (Zinc)
Commercial Road / Car Park (High Use)
Commercial Road / Car Park (Medium Use)
Pervious Surface
User Defined Paved 1
User Defined Paved 2
User Defined Paved 3
User Defined Roof 1
User Defined Roof 2
User Defined Roof 3
Surface
Asset ID
Node description
Contributing area (m2)
Land Use
Commercial Road / Car Park (High Use)

Water quality benefits linked to hydraulics i.e

surface water sewer: no runoff = no pollution

combined sewer: no runoff = improved capacity





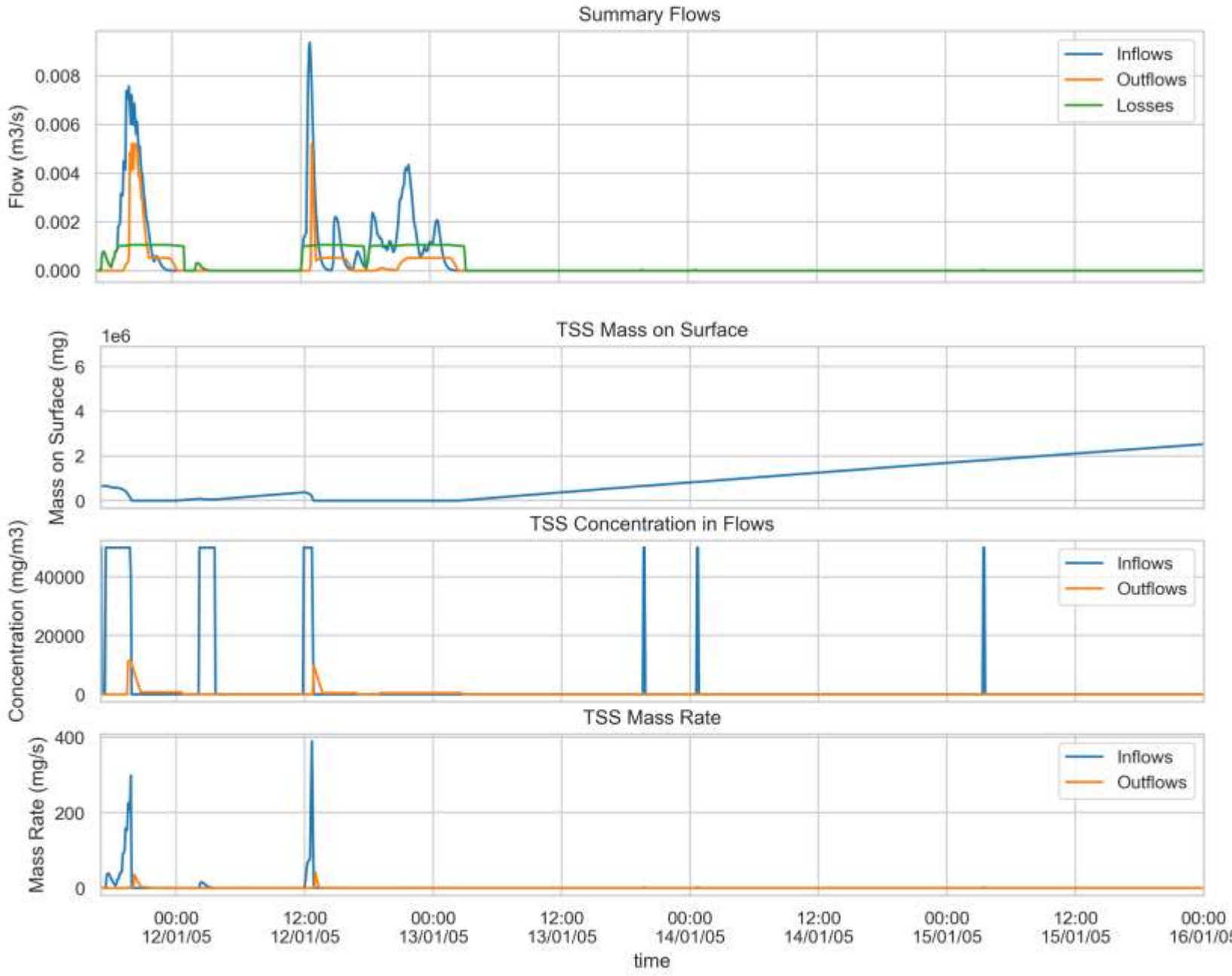
Water quality

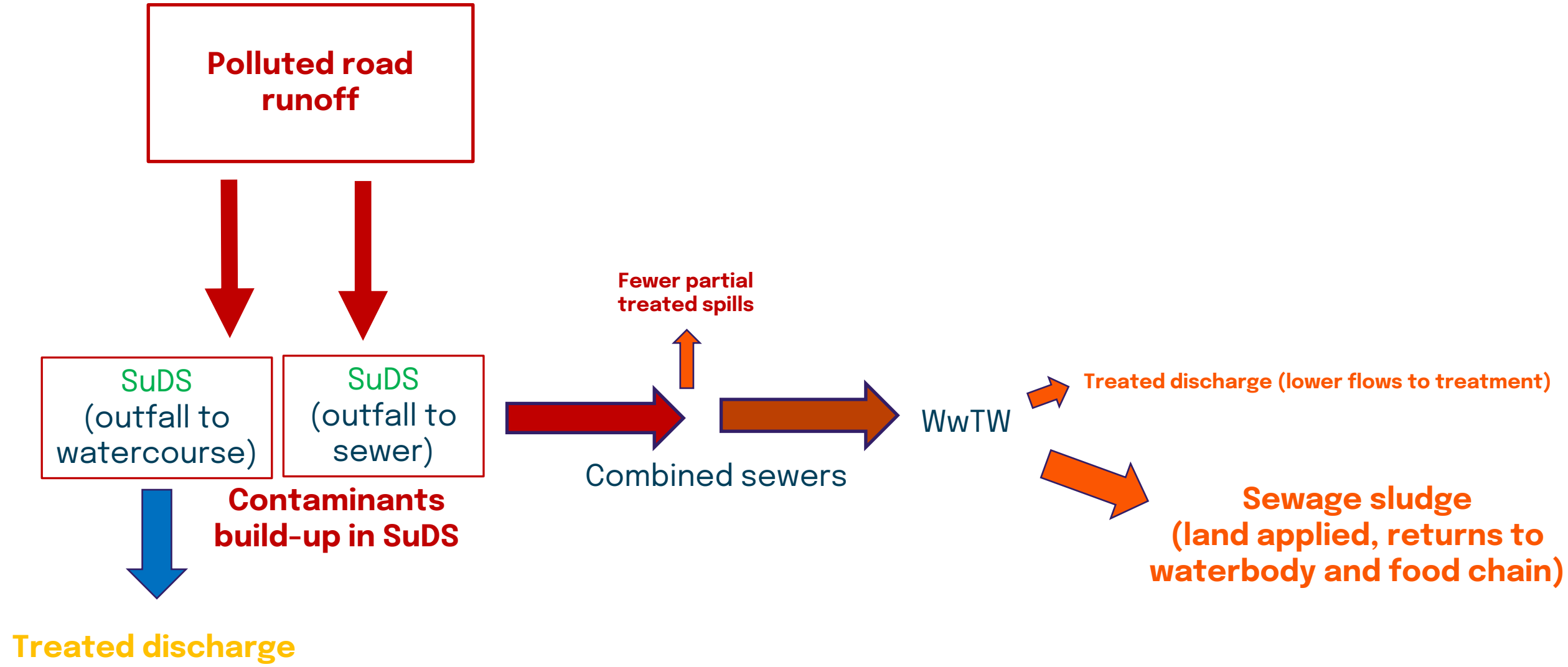
Inflows and outflows

Mass on contributing area surface

Concentration in SuDS inflows and outflows

Rate of movement of mass





ON-LINE SUDS BENEFITS

To conclude:

- Surface water has been, and continues to be, an overlooked threat
- A wide range of toxic, hazardous substances are present in stormwater runoff at levels that, in many cases, exceed those found in CSOs, treated wastewater effluent and EQSs
- The risk posed by surface water runoff should be considered alongside CSO improvements within catchment strategies
- There is pertinent research going on in Europe
- SuDS are a valuable part of integrated solutions
- Policy and regulation are likely to evolve… currently unclear how
- Need for better evidence, monitoring standards, and appropriate environmental standards: data is almost universally from outside of the UK

Thank you