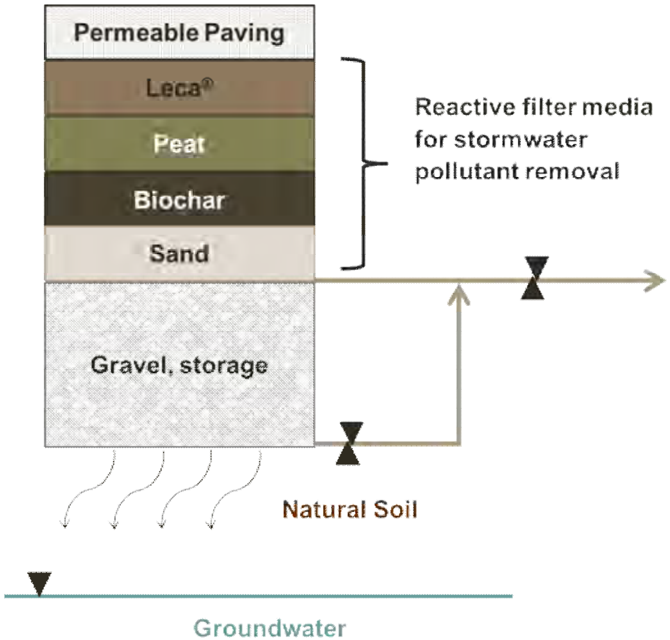
Kaupunkivesistöt kuntoon –hankkeen KICK OFF BIOHIILI-ILTAPÄIVÄ 30.11.2017, 12-16



StormFilter-projekti ja biohiili hulevesien puhdistamisessa, Juhani Korkealaakso ja Laura Wendling, VTT

http://www.vtt.fi/sites/stormfilter

VTT

STORMFILTER

- Objectives
- Methods
- Partners
- Research Team
- Events
- Links
- Reports

STORMFILTER – Engineered Infiltration Systems for Urban Stormwater Quality and Quantity, 2015-2017

STORMFILTER project description in English

STORMFILTER projektikuvaus suomeksi

The STORMFILTER project addresses the societal challenges of urban stormwater ma[...] targets are to generate knowhow to provide clean technologies, in the form of engine[...] designs that can enhance stormwater management by retaining runoff and improvi[...] pollutant sorption or filtering in the soil. The targets compliment Finnish strategies f[...] promoting vegetation health and improved water quality. The project also provides[...] decision making regarding regional planning and specifications, based on models [...] of performance for the new infrastructural solutions.

Urban cloudbursts and resulting rapid stormwater overflows along surfaces and [...] more common in cities due to the increasing extent of impervious surfaces, clim[...] infrastructure and often undersized, centralized stormwater networks. Urban st[...] of contaminants that can adversely impact receiving waters. Use of infiltration s[...] (such as green roofs and pervious pavements) without proper consideration of [...] status of urban ecosystems and water resources. The proposal targets developing material solutions and designs to clean stormwater, with quantitative values and models for the grey (subbase and hard surfacing) and green (vegetation) material solutions.

Aalto University

UNIVERSITY OF HELSINKI

STORMFILTER statistics

- 2.25 year duration, Sept 2015-2017
- VTT, Aalto, UnivHelsinki, TEKES, cities (4), companies (8 material/products), associations (1), designers (3), water management organizations (1)
- Partnership to Norwegian KLIMA2050-project

Engineered Infiltration Systems for Urban Stormwater Quality and Quantity Management (STORMFILTER)

VTT

Aalto University

Helsingin yliopisto

Tekes

Puutarhaviljelijät / Plantskolodlarna

ESPOO ESBO

City of Helsinki

MIKKELIN KAUPUNKI

Vantaa

cloud asset

weber SAINT-GOBAIN

onninen

MARKETAN PUISTO
MARGRETEBERGS PARK

PÖYRY

RAMBOLL

Leca

HSY

CLEAN WATERS

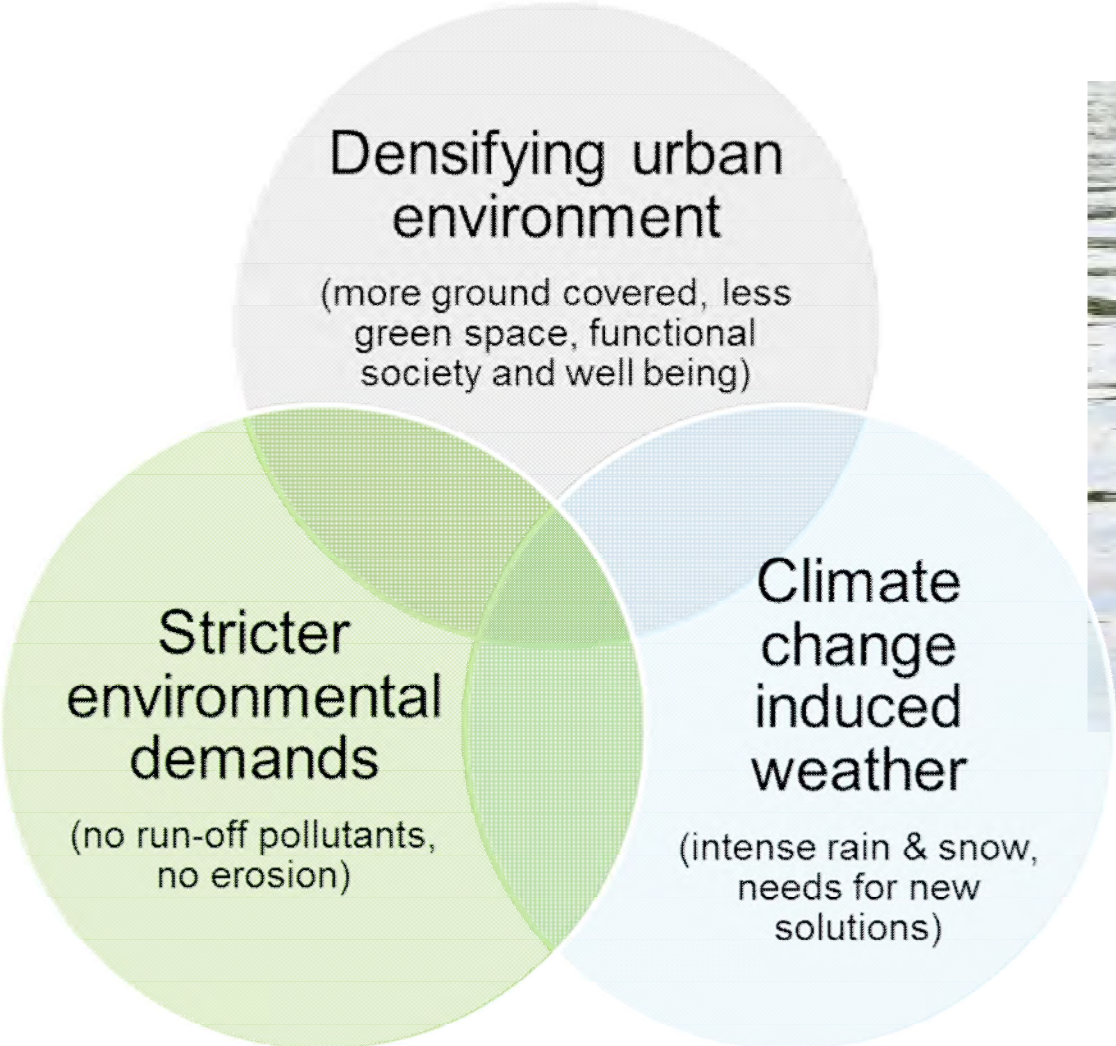
Rudus

P&H
RPK Hiili Oy

SITO

YRS
Ympäristösi valinta

Project motivation…



Project motivation: Stormwater runoff is a major cause of water pollution in urban areas (https://www.epa.gov/green-infrastructure/what-green-infrastructure)

- *Stormwater management and its role in the larger challenge of preservation of water quality around the world is an evolving issue. As commercial development continues at record levels, both the quantity of runoff and water quality are issues that need to be looked at carefully.*

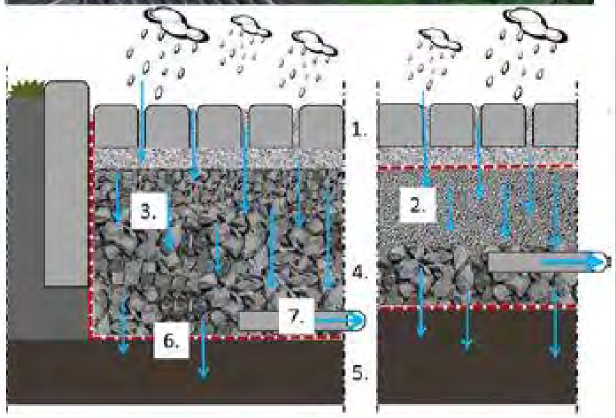
- *The engineering community is being pushed to design new solutions that keep groundwater and surface water ecology safe and that also protect development economics.*

Rethinking Water Infrastructure - Integrating Distributed Water Solutions…

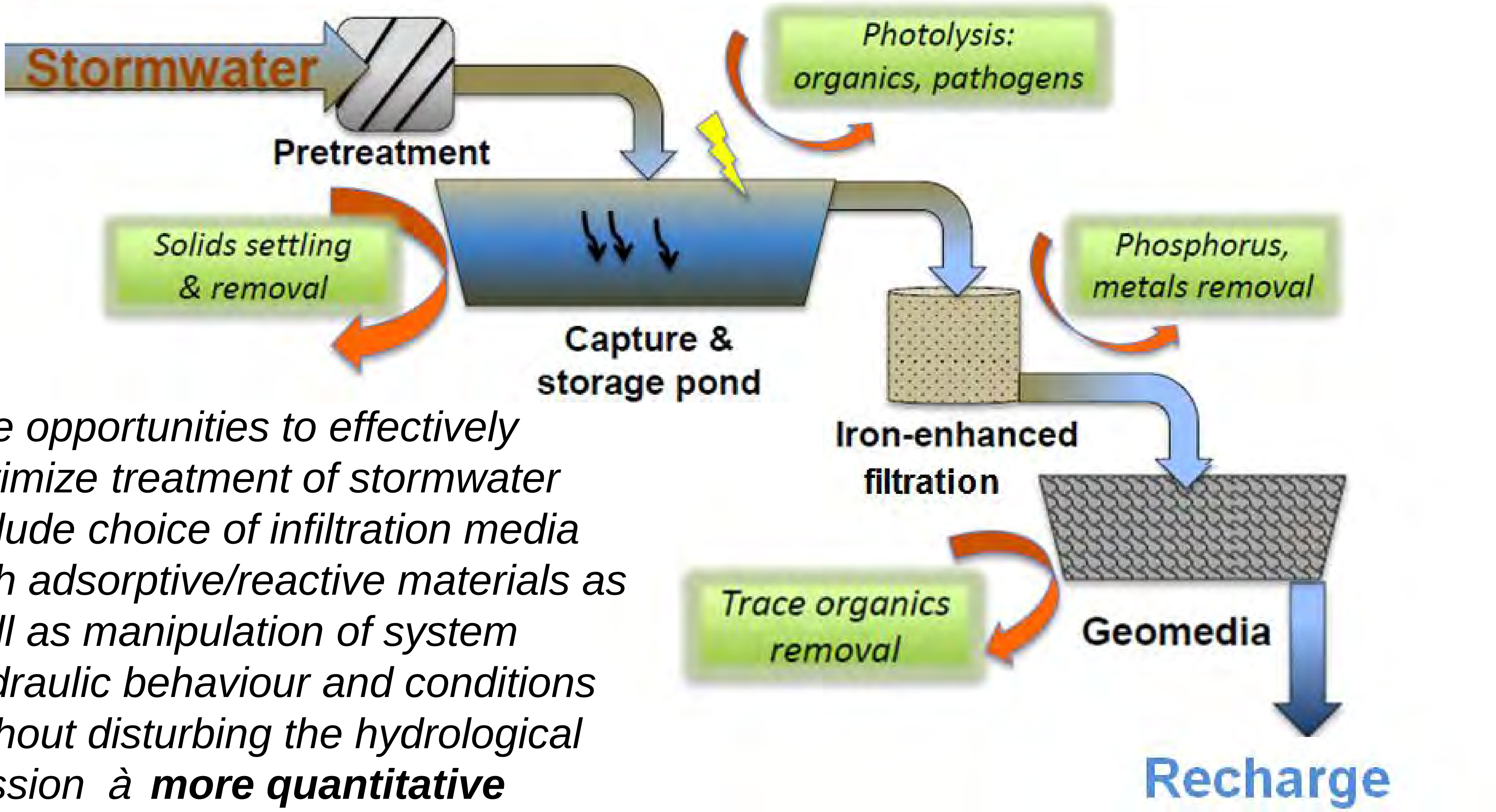
- ”Nature-based solutions” which mimic natural processes gaining popularity for (urban) water management
  - … lack consistent, rigorous engineering, real-time performance monitoring & control capability
  - Evidence of benefits largely qualitative

- **Need for genuine integration of blue-green-grey technologies & products**
  - Many technologies exist as individual products
  - Some technologies/ tools need to be optimised or further developed, e.g. for interoperability
  - Quantitative information about system performance, capacity (pollutant, hydraulic), maintenance needs, longevity & co-benefits, applicable environmental conditions, etc.



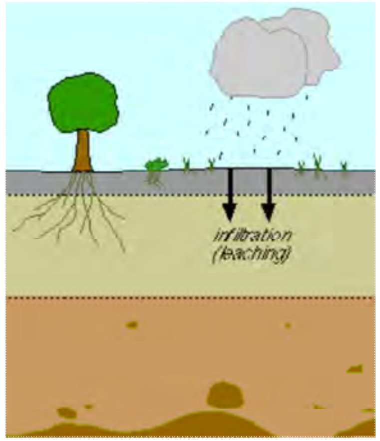
Example of Decentralized Stormwater Controls - Capture à Treatment à Recharge…



- *The opportunities to effectively optimize treatment of stormwater include choice of infiltration media with adsorptive/reactive materials as well as manipulation of system hydraulic behaviour and conditions without disturbing the hydrological mission à* ***more quantitative approaches needed***

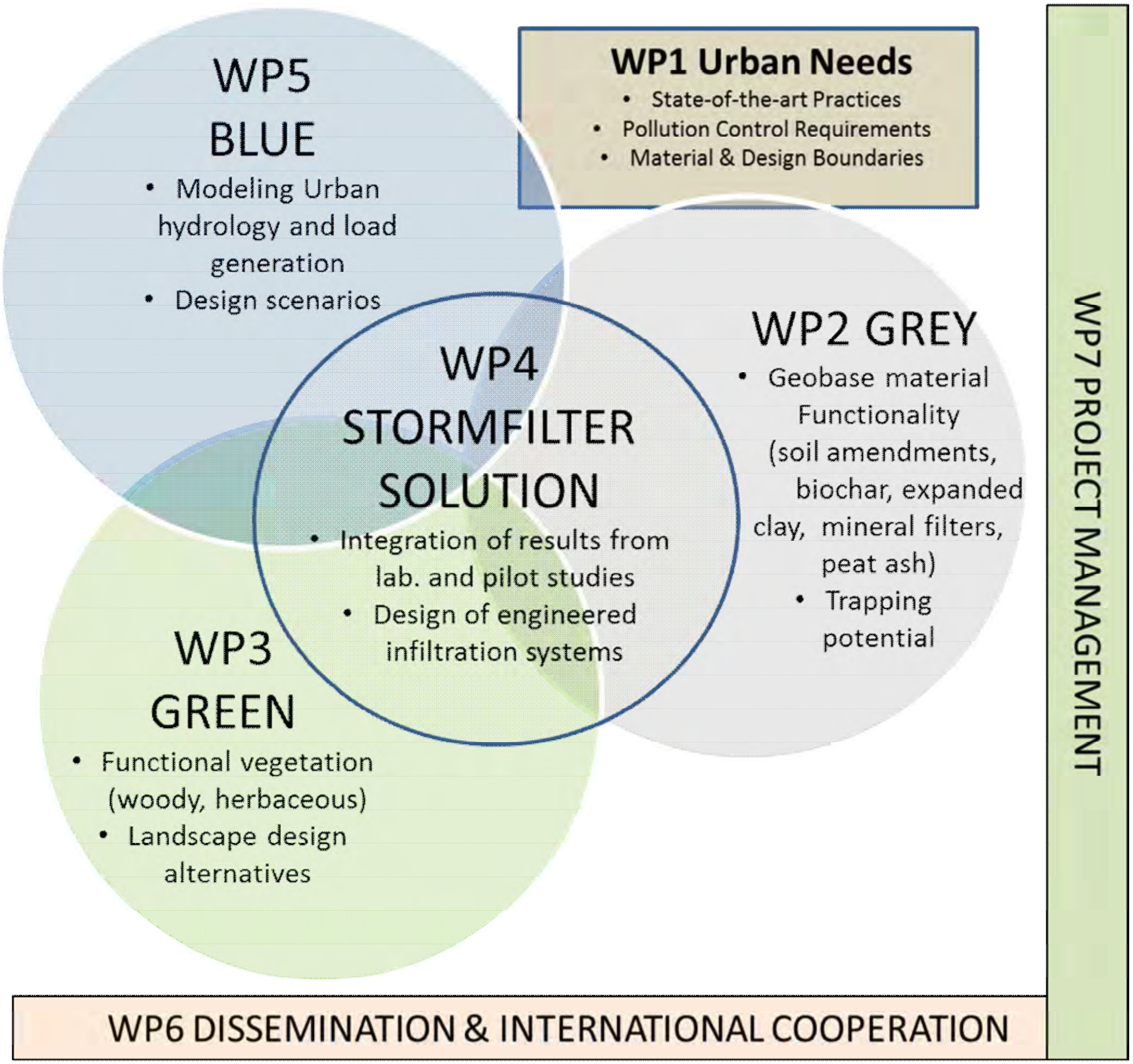
Filter materials for stormwater quality management - Project

StormFilter-project objectives:



- To ***generate new bio- and mineral-based solutions*** through materials produced by Finnish industry
- To ***evaluate material performances*** in various scales to ensure their applicability to Finland
- To ***create new business*** for project partners
- To ***promote new technologies*** that can help creating a better living environment for the increasingly dense population

STORMFILTER PROJECT FORMAT



EXAMPLE REFERENCES/EXPERIENCE OF R&D TEAM

- SmartAlarm – Real-time Alerting for urban floods (VTT, TEKES, 2010-12) https://www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/turvallisuus/safety-and-security-ohjelmaraportti/safety-and-security-explore-the-topics/safe-city-artikkelit/smartalarm_vtt.pdf
- CLASS – Climate Adaptive Pervious Surfaces to Reduce Urban Flooding (VTT, TEKES, 2012-14). http://www.vtt.fi/sites/class/en/
- Grey-Green Urban Systems for Water Management (SP/Sweden, Vinnova, 2012-14) http://www.greenurbansystems.eu
- URCA - Quality and Quantity of Runoff Water - Urbanised Catchments, (Aalto, AKA, 2012-16)
- Optimal design of hydrometric networks – the urban perspective, (Aalto, Maa- ja vesitekniikan tuki ry, 2012-16)
- Urbanization impacts on surface waters, (Aalto, Maa- ja vesitekniikan tuki ry, 2012 - 16)
- LIFE + KEIDAS Urban Oases – (Univ. Helsinki et al, EU, 2012-17). http://www.helsinki.fi/taajamakeitaat/

Filter materials for stormwater quality management - Background

§ Stormwater pollutants: Airborne

P
N
S
heavy metals,
hydrocarbons,
particulates

Rain absorption, deposition / absorption by roofs

Filter materials for stormwater quality management - Background

§ Stormwater pollutants: Ground surface, runoff

Hydrocarbons
Heavy metals
Bacteria
Viruses
P
N

Wear, leaks, litter, animal faeces, vegetation, de-icing,

Biochar in Sand and Biofilters for Industrial Stormwater Filtration

Port of Tacoma, West Hylebos Pier Log Yard

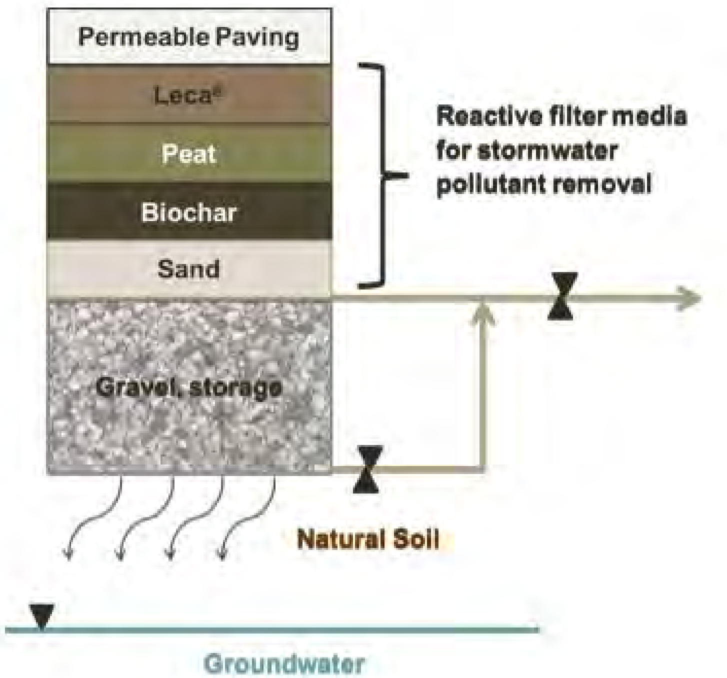
Photo: Kennedy Jenks, Port of Tacoma, West Hylebos Pier Log Yard

Up to 80% - 90% reduction in ISGP parameters: pH, Zinc, Copper, Turbidity, TSS & COD

Small Scale tests: 70% Sand + 30% Biochar to capture Copper and reduce Chemical Oxygen Demand (COD)

Deliverables

- D1.1 State-of-the-Art on international and domestic practices for cleaning of stormwater, including identification of legislation.
- D1.2 Report on material markets and production flow for *filtration media to be used in the stormwater cleaning*.
- D2.1 *Report on localized performance of bio- and mineral-based filtration material components, based on laboratory tests*
- D2.2 *Report on in-situ performance of filtration systems, based on field and in-situ tests*
- D4.1 Report on stormwater biofilter pilot in the city of Vantaa
- D4.2 Guideline on implementation of bio- and mineral based filtration systems to Finnish practice (in the draft phase)
- D5.1 Report on stormwater modelling in the pilot catchments. MSc thesis content (#2 from Aalto).
- D5.2 Report on stormwater model applications for assessing management designs. Including MSc thesis content (#3 from
- D6.1 Establishing project web page

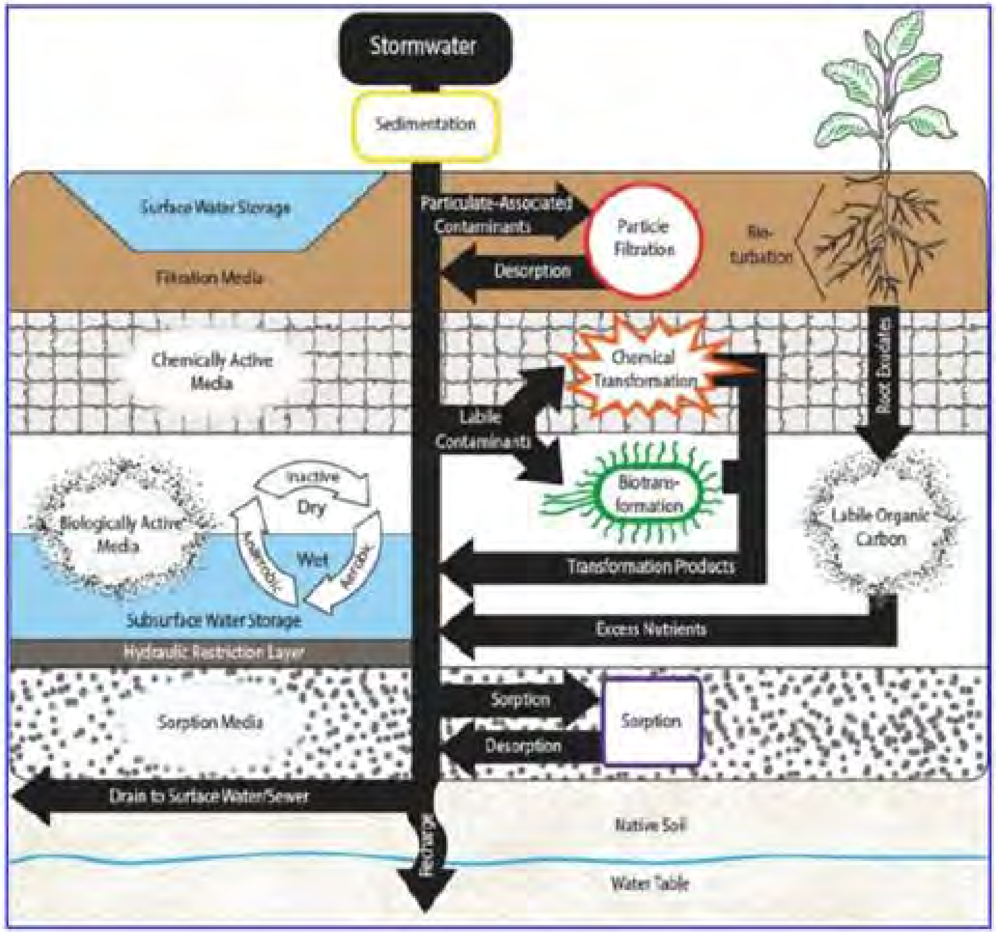


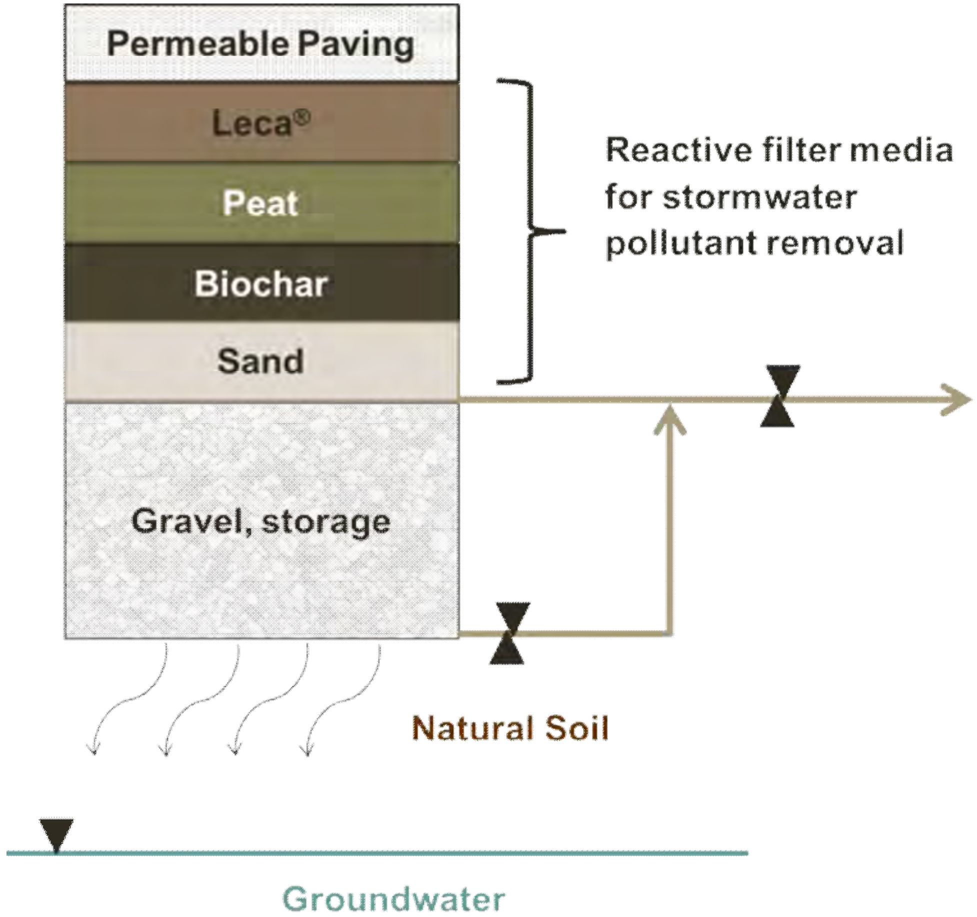
Integration of geochemical knowhow, experiments & modelling

VTT StormFilter WP2: Geo- & bio-based materials for stormwater filtration

Laura Wendling, Juhani Korkealaakso, Kalle Loimula, Hannele Kuosa, Hanna Iitti, and Erika Holt

Layered geotechnical modules





Biochar

- *Low density*
- *Moderate to high specific surface area*
- *Alkaline pH*

- *Text materials:*
- *Birch biochar (fine-textured)*
- *Spruce biochar*

Filter Materials

KaM 0-5 mm crushed
rock fines

Leca & Fe-coated Leca,
crushed 3-8 mm

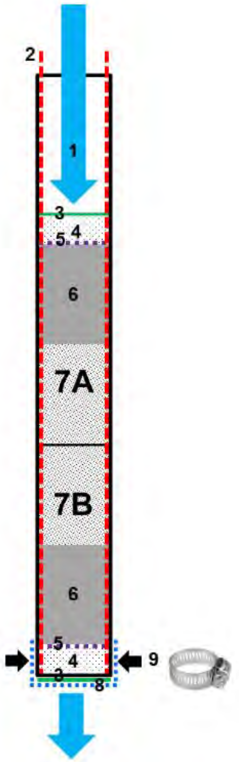
Spruce biochar & Fe-treated
spruce biochar

Peat: 90 wt.% peat + 10 wt. % $CaCO_3$

Filter materials for stormwater quality management - Project

§ Research methods / scales:

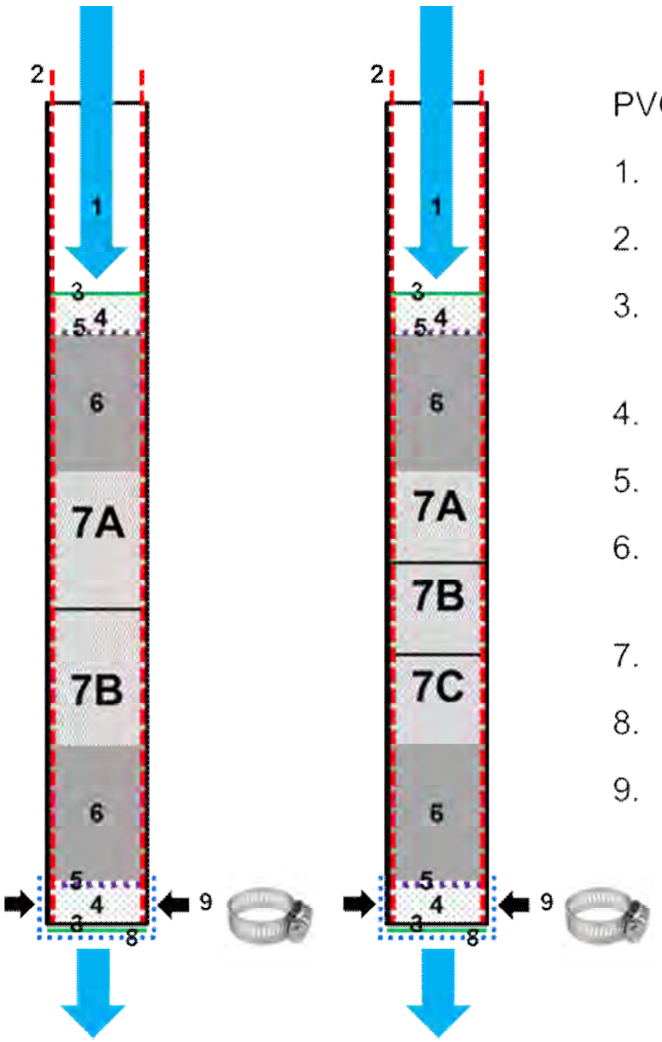
Batch
~0,15kg,1.5 L



Column
~1-3 kg, 40 L

0.5m^3 Box
~>100kg, 600 L

Experimental design: column tests



PVC pipe: H 900 mm, Ø 110 mm

1. Influent stormwater
2. Cellular foam lining (flexible, *ca.* 5 mm)
3. 40 mm coarse aggregate (high hydraulic conductivity)
4. Screen plate
5. Mesh screen
6. 150 mm aggregate KaM 0-5 mm (low hydraulic conductivity)
7. 300 mm layered filter material
8. Mesh or woven glass cloth
9. Hose clamp

	Phase 1, 0-33 L	Phase 1, 33-40.5 L	Phase 2
	1X Concentration (µg/l)	20X Concentration (µg/l)	10X Concentration (µg/l)
Cu	500	10 000	5 000
Pb	1 000	20 000	10 000
Zn	2 000	40 000	20 000
Total P	500	10 000	5 000
Cl	100 000	140 000	-
SO_4	80 000	94 000	-
Organic carbon	10 000	10 000	-

Synthetic stormwater influent

	Pollutant concentration (µg/L)
Cu	5 000
Pb	10 000
Zn	20 000
Total P	5 000

Results Summary: Individual Materials

- An appropriately sized structure employing any of the tested filter materials could effectively remove Cu, Pb & Zn from influent stormwater
- Any filter materials tested, except birch biochar, could effectively remove P from influent stormwater
  - **Strong concentration effect**: P release in 'normal' dilute stormwater; P retention followed by release in 10X concentrated stormwater, P retention in 20X concentrated stormwater
  - Birch biochar could be expected to initially release P, followed by net P sorption depending on influent concentration – additional characterisation required prior to use near ecologically sensitive waterbodies
- Lack of substantial differentiation between pollutant removal by "unreactive" filter materials & those known to possess high cation exchange capacity or specific surface reactivity towards phosphate ions
  - Suggests primarily physical or a combination of physical and chemical metal & P retention
  - **Strong pH effect**

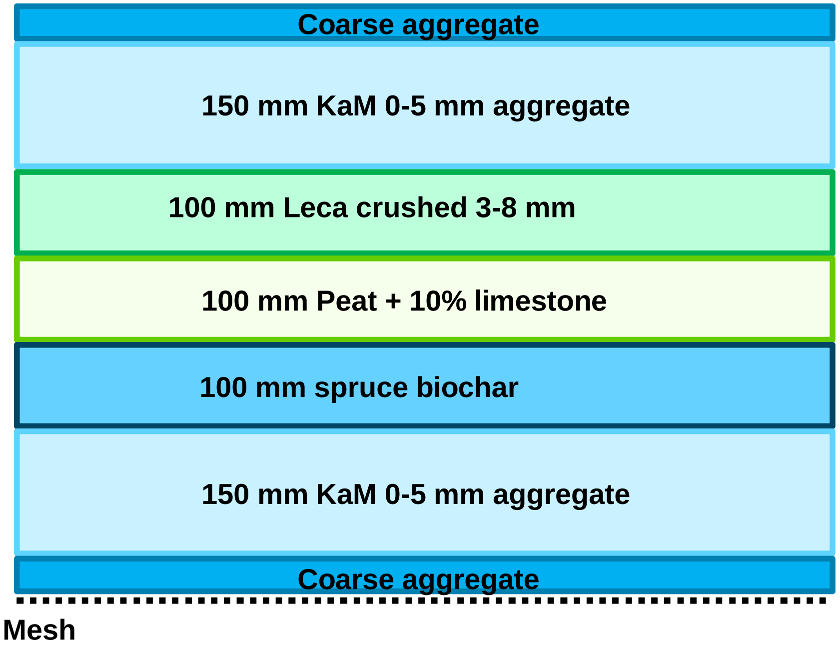
Layers or Mixtures Tested

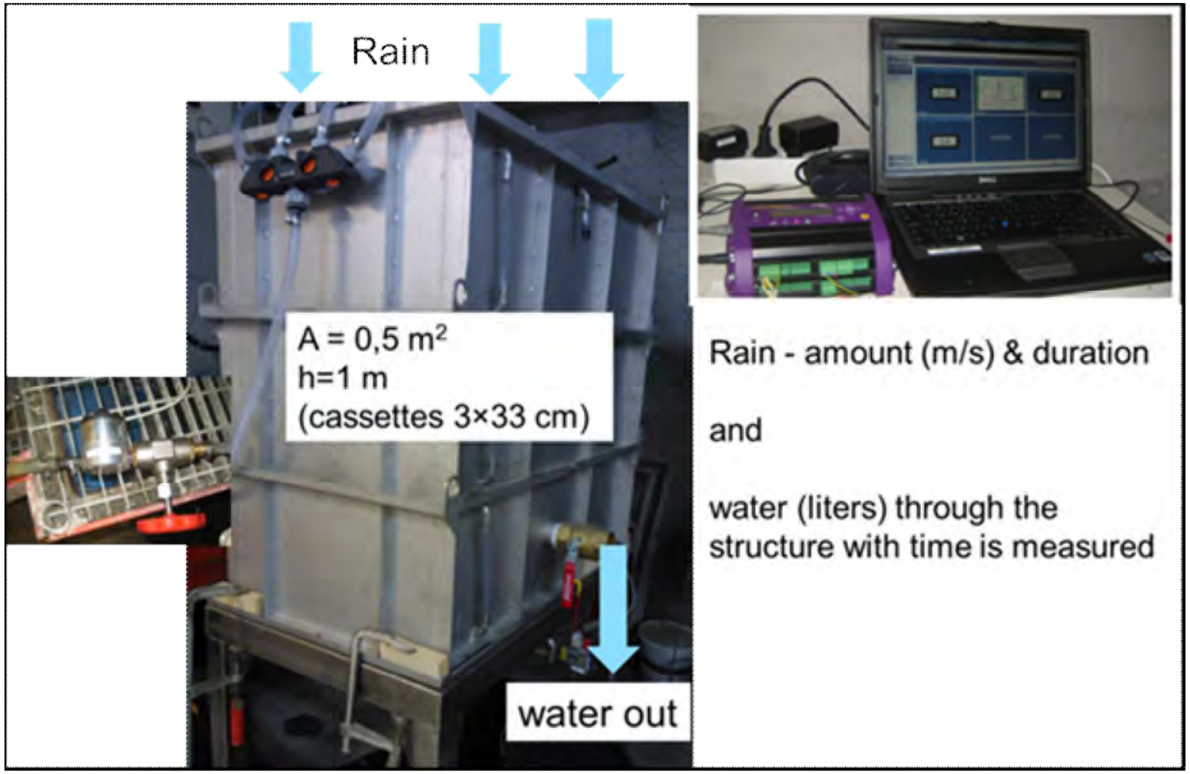
- Six different layered or homogeneously mixed filter systems were examined in laboratory column experiments:
  - 3–8 mm crushed Leca® / Peat + 10 wt.% limestone / Spruce biochar
  - 3–8 mm crushed Leca® / Peat + 10 wt.% limestone / Iron-treated spruce biochar
  - Iron-coated 3-8 mm crushed Leca® / Peat + 10 wt.% limestone / Spruce biochar
  - Homogeneous mixture of 10% spruce biochar - 90% 0–2 mm quartz sand
  - 3–8 mm crushed Leca® / Peat + 10 wt.% limestone
  - 3–8 mm crushed Leca® / Spruce biochar

- Each layered or mixed system was also comprised of layers of KaM 0/5 aggregate above and below

- Infiltration rig experiment contained KaM 0/5 + 3–8 mm crushed Leca® / Peat + 10 wt.% limestone / Spruce biochar

Meso-scale testing of layered materials using infiltration rig





+ Geochemical modelling to evaluate mechanisms of attenuation

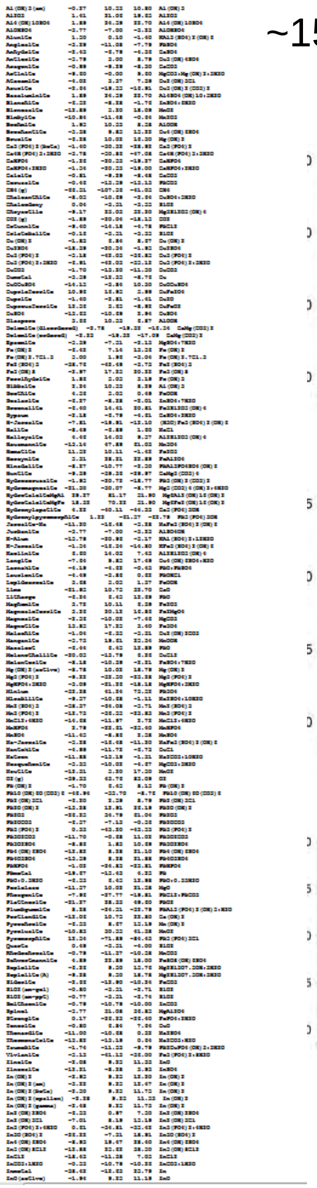
Summary of layered filter system performance

- The small (column)-scale layered or mixed filter materials removed:
  - 81–97% Cu
  - 84–97% Pb
  - 50–96% Zn
  - 42–81% P
- The up-scaled filter system removed:
  - 87–99% Cu, Pb & Zn
  - >80% P
- Fe-treatment of biochar & Leca® substantially improved phosphorus & to a lesser extent zinc retention
- Cu, Pb & Zn removal rates were superior to/ comparable with literature values for similar materials
- A combination of surface adsorption & (co)precipitation reactions likely contributed to metal & phosphorus removal from stormwater

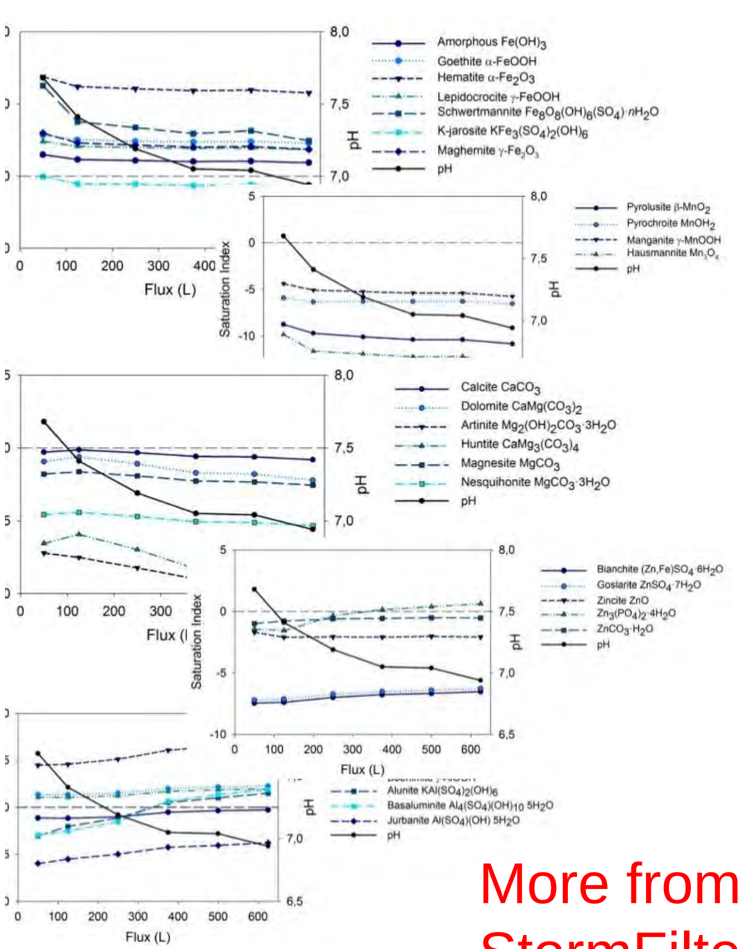
Implications

- Assuming no significant changes in pH or oxidation-reduction potential:
  - Removed P is strongly retained & unlikely to be re-mobilised
  - Reasonable long-term stability of retained metals within filter materials
  - Est. Lifespan 5-10+ years depending on dimensioning
- Release of retained Zn from filter materials would indicate that filter's stormwater purification capacity is exceeded/ filter needs to be renewed
  - Declining rates of Zn retention would indicate approaching end of functional lifespan
- Difference in pollutant retention efficiency between analogous filter systems suggests that greater volume/ mass of filter material = more effective treatment of stormwater runoff.
  - Highlights the importance of hydraulic modelling and load estimation for the scaling of filter systems not only for flood control, but also for stormwater quality improvement.

Geochemical modeling



~150 phases in total



More from:
StormFilter Material Testing Summary Report

ENGINEERED INFILTRATION SYSTEMS FOR URBAN STORMWATER QUALITY AND QUANTITY MANAGEMENT (STORMFILTER)

FINAL WORKSHOP - AGENDA

Time: 14. November 2017, 9.00–16.30
Place: GTK Auditorium, (Betonimiehenkuja 4, Espoo)

9.00	Coffee
9.15	**Welcome and Introduction** *Jukka Saarenpää, Steering Group Chairperson (Onninen Oy)*
9.25	**Project motivation** Juhani Korkealaakso, Project Manager (VTT)
9.40	**SESSION 1: Urban Stormwater Challenges,** Chair: Juhani Korkealaakso (VTT) **Laura Karhumäki** (City of Espoo) **Heikki Takainen** (City of Helsinki)
10.05	**SESSION 2: Materials for Stormwater Filtration,** Chair: Kalle Loimula (VTT) **Mikko Pöysti** (Leca Finland Oy) **Mika Tulimaa** (Rudus Oy) **Jaakko Soikkeli** (Vapo Clean Waters Oy) **Kaisa Neuvonen** (RPK Hiili Oy)
10.50	**SESSION 3: Vegetation for Stormwater Pollution Control,** Chair: Outi Wahlroos (UHel) **Outi Wahlroos** (University of Helsinki) **Marta Angervuori** (Marketanpuiston ystävät ry)
11.30	Lunch
12.30	**SESSION 4: Modelling as a Stormwater Management Tool,** Chair: Harri Koivusalo (Aalto University) **Lauri Harilainen** (SITO Oy) **Camilla Tuomela** (Aalto University) **Eero Assmuth** (Aalto University)
13.05	**SESSION 5: International Perspective on Nordic Stormwater Management,** Chair: Laura Wendling (VTT) **Edvard Siverstein** (SINTEF) **Tone Muthanna** (Norwegian University of Science and Technology, NTNU)
13.50	Coffee
14.20	**SESSION 6: Implementing Stormwater Solutions,** Chair: Nora Sillanpää (Aalto University) **Tommi Fred** (Helsingin seudun ympäristöpalvelut -kuntayhtymä HSY) **Tiia Valtonen** (Ramboll Oy) **Terhi Renko** (Pöyry Finland Oy) **Antti Auvinen** (City of Vantaa)
15.05	**PANEL DISCUSSION – lessons learned, and new or emerging opportunities,** Chair: Jukka Saarenpää, Steering Group Chairperson (Onninen Oy) Panel: Juhani Korkealaakso, Harri Koivusalo, Outi Wahlroos, Edvard Siverstein
15.50	**Tekes Perspectives on Project Achievements** **Tuomas Lehtinen** (Tekes)
16.00	**SUMMARY and WAY FORWARD** **Terhi Kling** (VTT) **Erika Holt** (VTT)

Still coming…

Contents of Guidelines

1. Introduction
2. General principles for enhanced pollution control
3. New materials, material selection and/or modification and combinations of materials
4. Modelling tools for enhanced stormwater management
5. Design and dimensioning for enhanced (Nordic) stormwater management
6. System monitoring & maintenance
7. Knowledge gaps (research needs)
8. Case Study Example(s)

Kiitos !