# Ceramic microfiltration; a novel and compact process for the treatment of surface water

**Water management: Challenges in cold climate, 25th June 2016**

**Chris Rockey, David Metcalfe, Gilbert Galjaard, Holly Shorney-Darby and Jumeng Zheng**

# Acknowledgement

SOUTH WEST WATER






# Contents

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- Motive and opportunity
- In-line coagulation, ceramic microfiltration
- DOC, membrane fouling and DBPs
- Full scale application/footprint

# Who we serve…


Barnstaple
Exeter
Plymouth
Truro
Penzance
Edinburgh
Glasgow
Dublin
Birmingham
Bristol
London
Exeter
SOUTH WEST

# Motive...

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# Opportunity

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Interreg 2 Seas Mers Zeeën DOC2C's

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De Watergroep

Université de Lille

TU Delft

# Reviewed and re-stated treatment goals

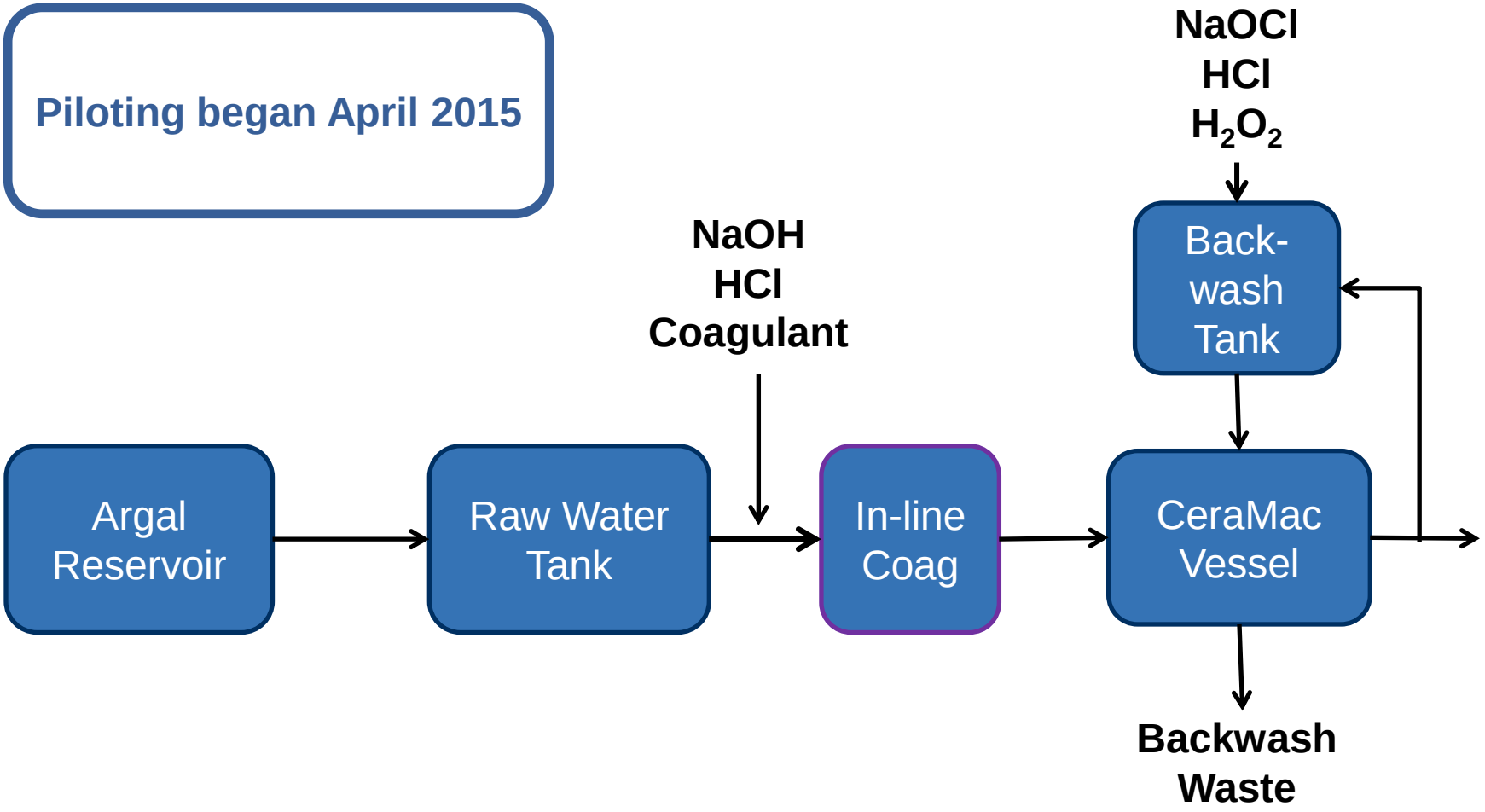
- **Absolute Barrier to Cryptosporidium**
- **DOC / disinfection by product reductions**
- **Very compact, forward looking design**
- **Highly automatable, robust and efficient process**
- **Environmental impact/sustainability**
- **Keep consumer bills down in long term**

# Ceramic membranes

- Filtration area 25$m^2$ , 180mm x 1500mm
- Size of monolith cost effective
- $Al_2O_3$ base layer $TiO_2$ top layer = 0.1um
- Close to 100 plants, no integrity failures
- High solids loading – direct river???
- Mechanical wash at high pressure
- Chemical cleaning options?
- Cost and recovery issues when applied traditionally

# Pilot testing

**Piloting began April 2015**



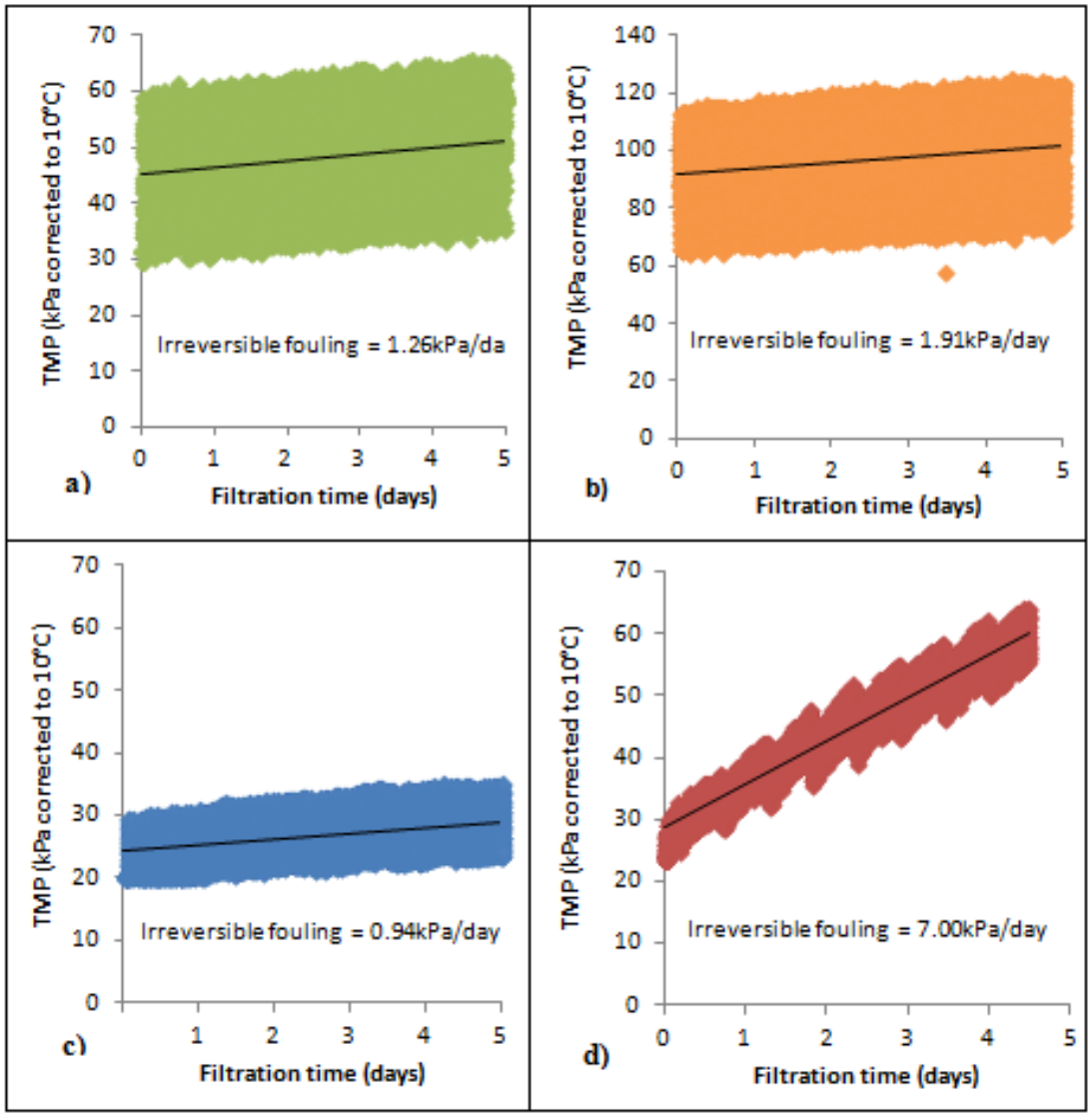
# Critical flux testing

a) 150 lmh low algal loading

a) 200 lmh low algal loading

a) 200 lmh high algal loading

a) 250 lmh high algal loading



# Membrane fouling / sustainable flux

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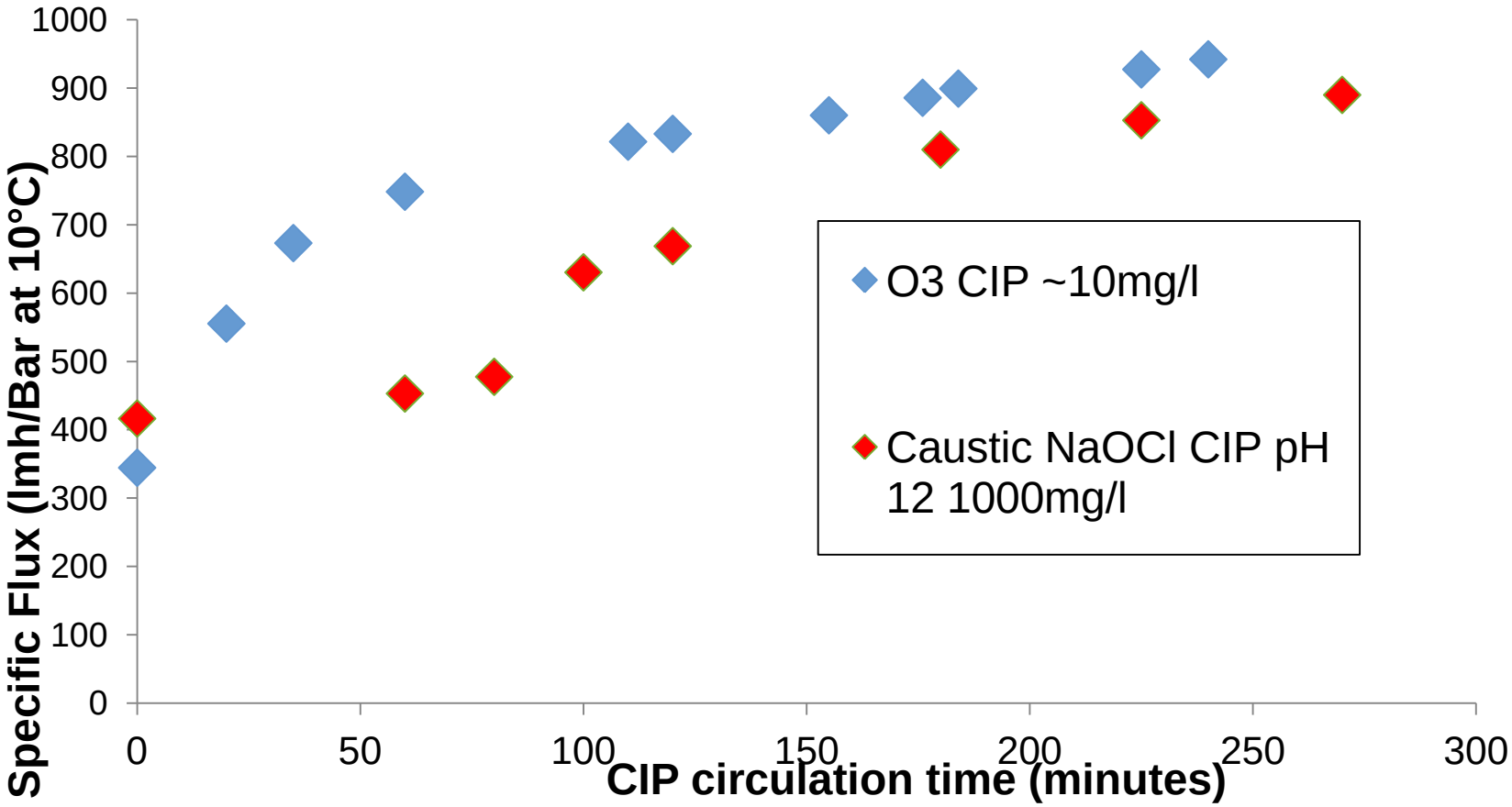
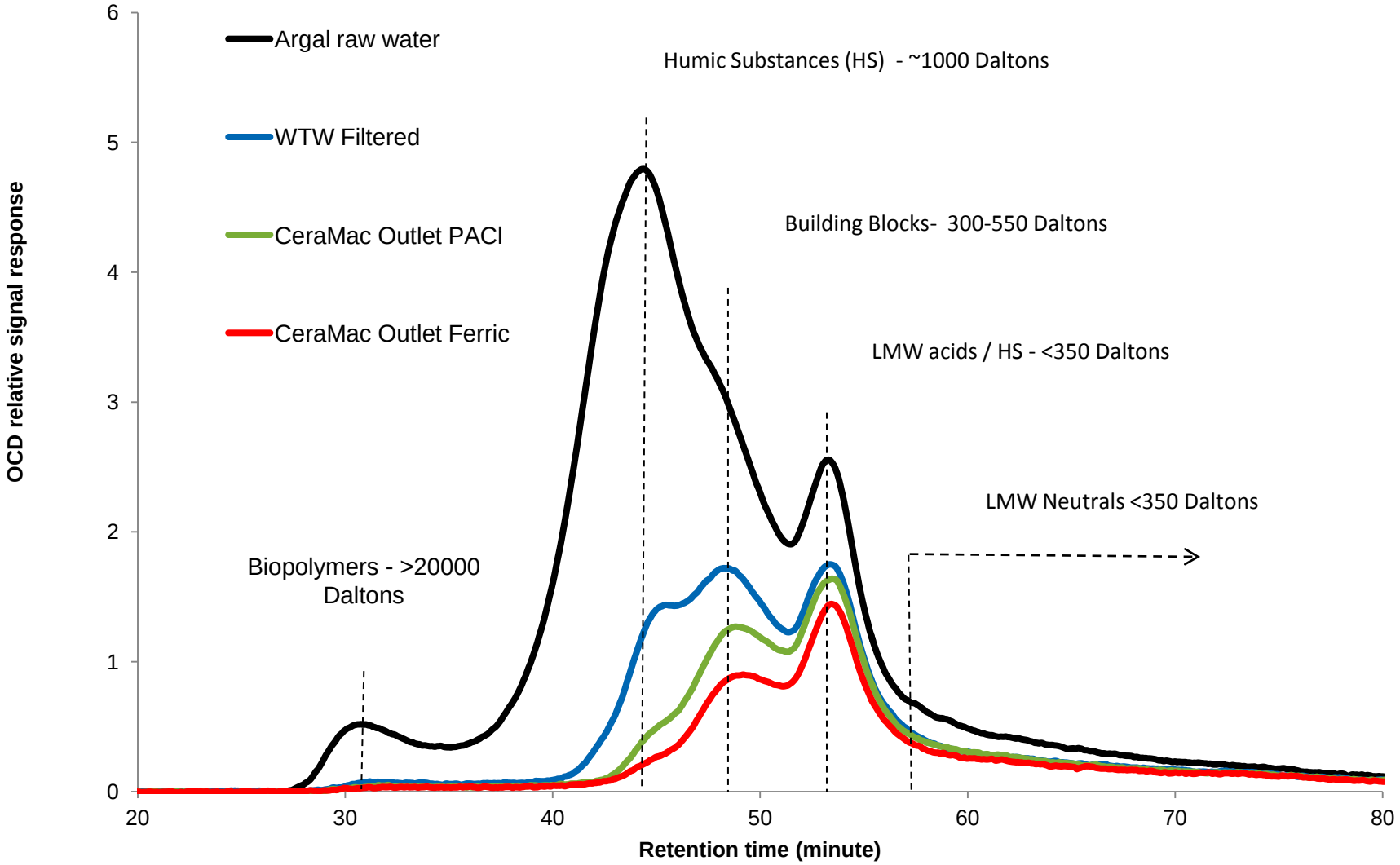
- Higher flux (SLR) = less membranes = lower cost
- Low fouling = simplifies operation, lowers pumping pressure, reduces frequency of chemical cleans
- Sustainable flux determined as **c185/136lmh**

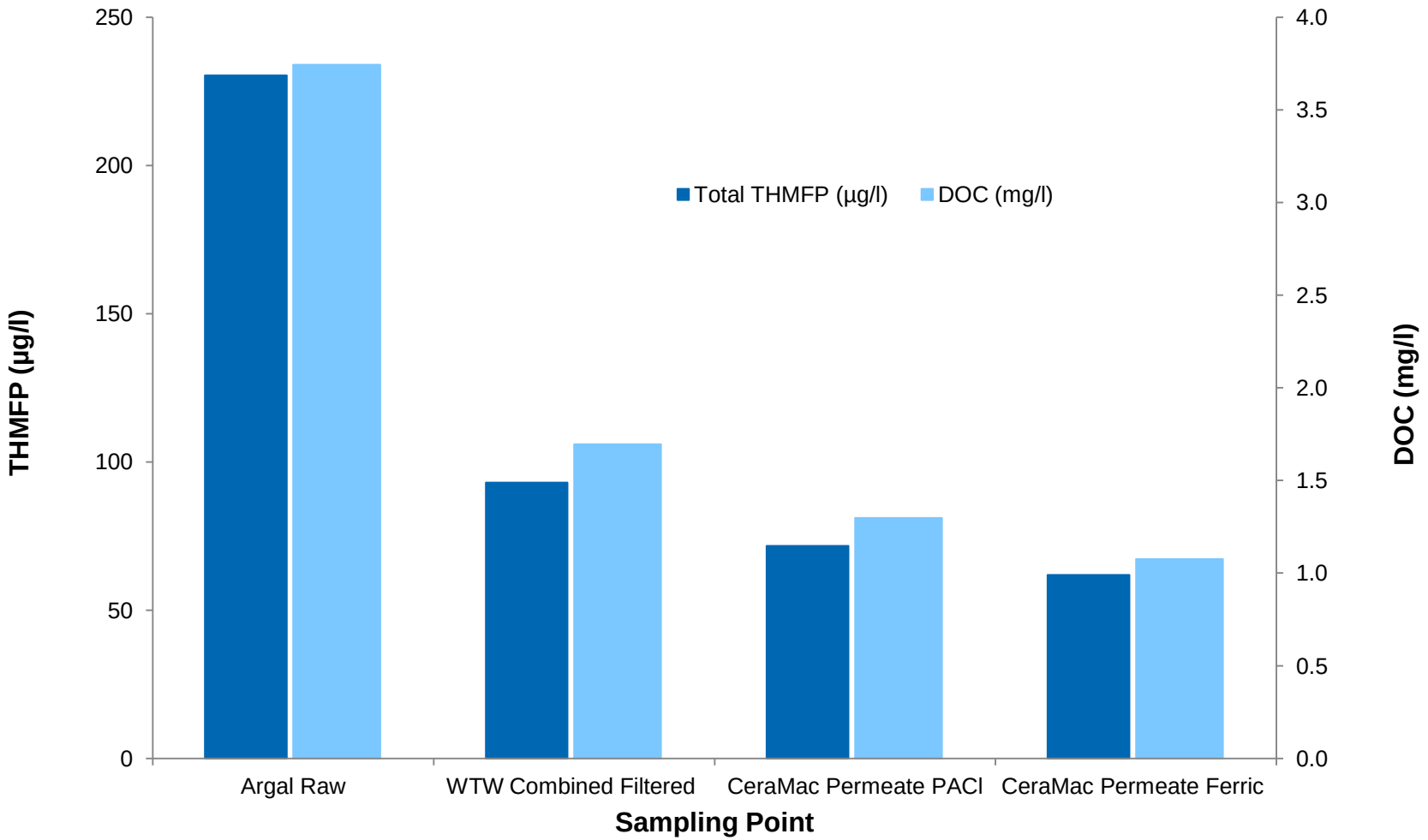
# Alternative CIP approach



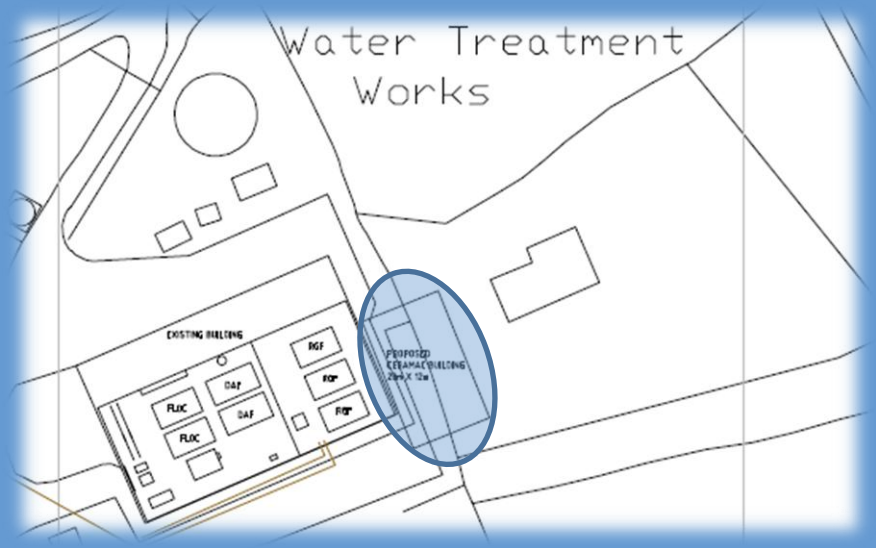
# LC-OCD organic removal comparison

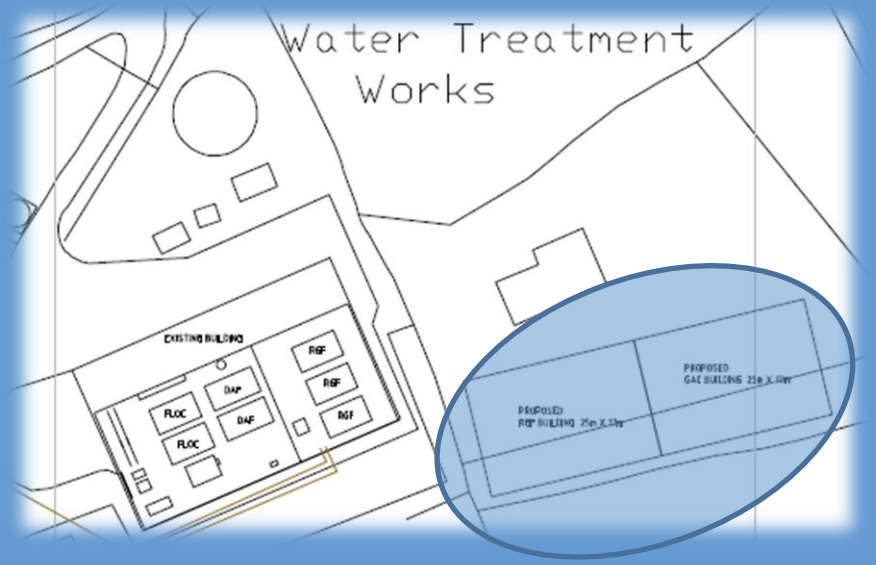


# By products

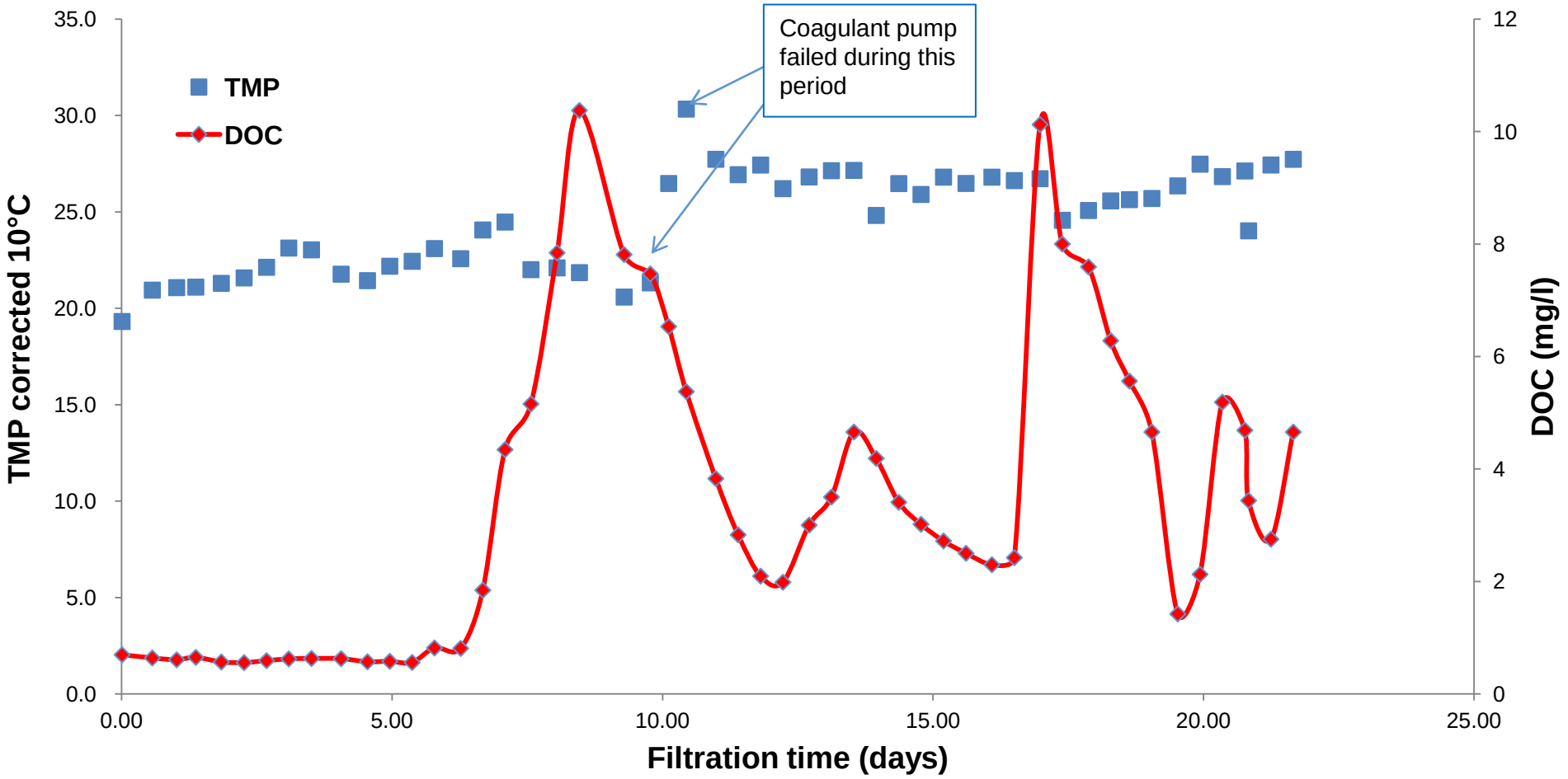

250
200
150
100
50
0
THMFP (µg/l)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
DOC (mg/l)
Total THMFP (µg/l)
DOC (mg/l)
Argal Raw
WTW Combined Filtered
CeraMac Permeate PACl
CeraMac Permeate Ferric
Sampling Point

# Footprint reduction and buildability




# Optimised membrane operation during spates




Optimised inline coagulation was critical to stable membrane operation. Using an automated coagulant control system it was possible to run at very high flux (185 LMH), during periods of extremely variable raw water quality (river spate conditions), with very low membrane fouling

# Mean % removal SIX/ILCA vs. conventional

| Parameter | SIX/ILCA/CeraMac additional removal relative to conventional treatment (%) |
|---|---|
| DOC (% Reduction) | 50 |
| UVA (% Reduction) | 62 |
| THMFP (% Reduction) | 62 |
| HAAFP (% Reduction) | 62 |
| THMFP Reactivity (% Reduction) | 22 |
| HAAFP Reactivity (% Reduction) | 18 |
| Brominated DBPFP (% Reduction) | 47 |

- DBPFP reduction was not only due to enhanced DOC removal, but also to reduced concentrations of Br-DBPs and selective removal of reactive organic compounds

# Publications

SOUTH WEST WATER

CRANFIELD UNIVERSITY

David Christopher Metcalfe

Application of Suspended Ion Exchange, In-line Coagulation and Ceramic Membranes for Surface Water Treatment

School of Applied Science
MSc by Research

Master of Science
Academic Year: 2014 - 2016


Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Removal of disinfection by-product precursors by coagulation and an innovative suspended ion exchange process

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Keywords:
Ceramic membrane filtration
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Natural organic matter

ABSTRACT

This investigation aimed to compare the disinfection by-product formation potentials (DBPFPs) of three UK surface waters (1 upland reservoir and 2 lowland rivers) with differing characteristics treated by (a) a full scale conventional process and (b) pilot scale processes using a novel suspended ion exchange (SIX) process and inline coagulation (ILCA) followed by ceramic membrane filtration (CMF). Liquid chromatography-organic carbon detection analysis highlighted clear differences between the organic fractions removed by coagulation and suspended ion exchange. Pretreatments which combined SIX and coagulation resulted in significant reductions in dissolved organic carbon (DOC), UV absorbance (UVA), trihalomethane and haloacetic acid formation potential (THMFP, HAAFP), in comparison with the SIX or coagulation process alone. Further experiments showed that in addition to greater overall DOC removal, the processes also reduced the concentration of brominated DBPs and selectively removed organic compounds with high DBPFP. The SIX/ILCA/CMF process resulted in additional removals of DOC, UVA, THMFP, HAAFP and brominated DBPs of 50, 62, 62, 62% and 47% respectively compared with conventional treatment.


Contents lists available at ScienceDirect

Separation and Purification Technology

journal homepage: www.elsevier.com/locate/seppur

Pre-treatment of surface waters for ceramic microfiltration

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Pretreatment
Ion exchange
Coagulation
Organic fouling

ABSTRACT

The influence of pre-treatment on the suppression of irreversible (IR) fouling of ceramic membranes challenged with three UK surface waters has been studied at pilot scale. An initial scoping study compared the efficacy of suspended ion exchange (SIX) and clarification (coagulation followed by sludge blanket clarification) individually and in combination. Direct membrane filtration following in-line coagulation (ILCA) was also investigated with and without SIX. The impact on the various organic fractions, specifically high molecular weight (HMW) biopolymers (BPs) and humic substances (HSs), and lower molecular weight (LMW) building blocks (BBs) and neutrals, was studied using liquid chromatography-organic carbon detection (LC-OCD).

Results revealed SIX and coagulation to preferentially remove the LMW and HMW organic fractions respectively. Residual HMW organic matter (primarily BPs) following SIX pre-treatment were retained by the membrane which led to rapid irreversible fouling. Coagulation pre-treatment provided stable membrane operation and the residual LMW organics were not significantly retained by the membrane. Combining clarification and SIX resulted in significantly increased removal of organics and lower mem-

# Summary

- Innovation from knowledge – small investment for a long term gain
- New supplies for the people of Falmouth and Plymouth
- Special projects for the SW just when we needed it

# Acknowledgments...

SOUTH WEST WATER

Cranfield UNIVERSITY

Rwb waterservices

DOC2C's

HET WATERLABORATORIUM

Interreg
2 Seas Mers Zeeën
DOC2C's
European Regional Development Fund

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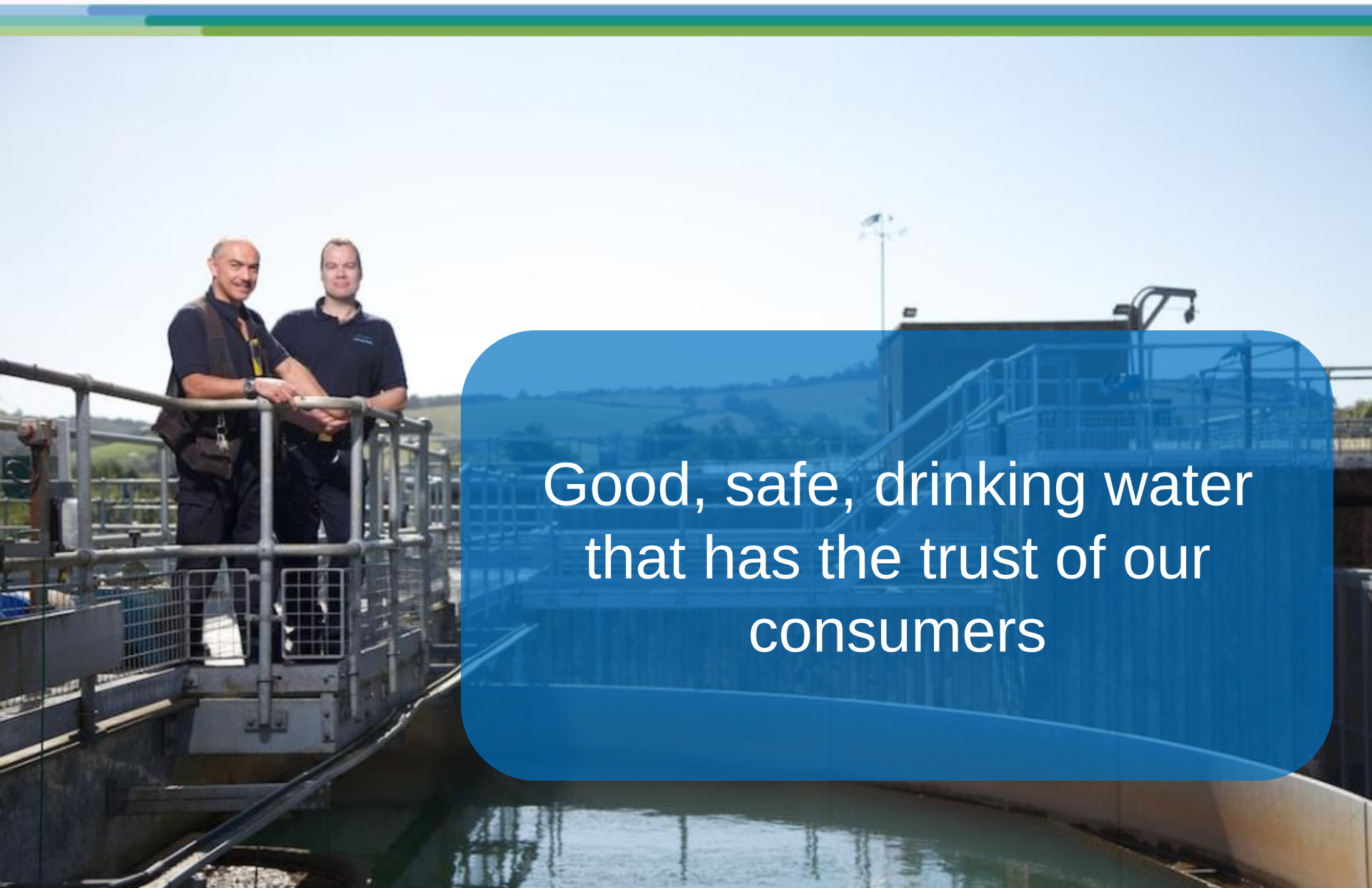
De Watergroep

Université de Lille

TU Delft

# Thank you


Good, safe, drinking water that has the trust of our consumers