21 OCTOBER 2021

16:00 CEST

IWA Specialist Group on Modelling and Integrated Assessment Webinar Series

Modelling Wastewater Treatment Resilience for Improved Decision Making and Resource Recovery

Speakers

Ulf Jeppsson
Lund University

Lluís Corominas
Catalan Institute for Water Research

Timothy Holloway
University of Portsmouth

Guangtao Fu
University of Exeter

Seda Sucu
University of Portsmouth

Maria Molinos-Senante
Pontificia Universidad Católica de Chile

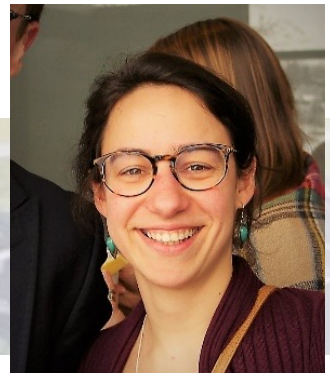
The webinar is going to be recorded and shared on the MIA SG Youtube channel afterward.

MIA Welcome Note

IWA Modelling and Integrated Assessment Specialist Group

Dr. Ulf Jeppsson (Chair of MIA SG)

Dr. Elena Torfs (Vice-chair of MIA SG)



inspiring change

Lund University

Ghent University

MODELLING AND INTEGRATED ASSESSMENT SPECIALIST GROUP (MIA SG)

"This group targets people from research, consulting companies, institutions and operators to think along ***the use of models and computing tools to support the understanding, management and optimization of water systems****."*

PRIORITIES

- Interact with other IWA SGs and other professional organizations
- Organize specialized conferences, sessions and workshops
- Engage and activate YWPs in the domain.

CURRENTLY 1900 MEMBERS

How to find us

Website: http://iwa-mia.org/

https://iwa-connect.org

MIA SG: ACTIVITIES

Task Groups (TGs)

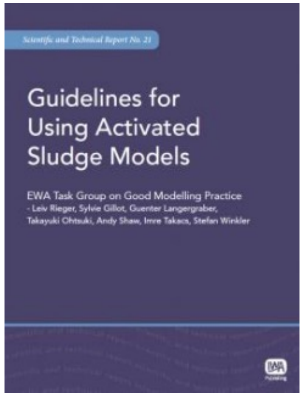
- Benchmarking of Control Strategies for WWTPs (BSM) AND Good Modelling Practice (GMP) (Both finished)
- Design and Operations Uncertainty (DOUT)
- Generalised Physicochemical Modelling (PCM)
- Use of Modelling for Minimizing GHG Emissions from Wastewater Systems (GHG)
- Membrane Bioreactor Modelling and Control (MBR)
- Good Modelling Practice in Water Resource Recovery Systems (New)

Working Groups (WGs)

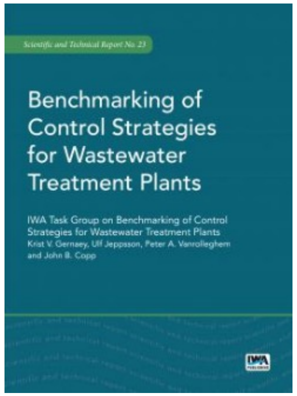
- Integrated Urban Water Systems (IUWS)
- Computational Fluid Dynamics (CFD)
- Good Modelling Practice (GMP)

Conferences / Events

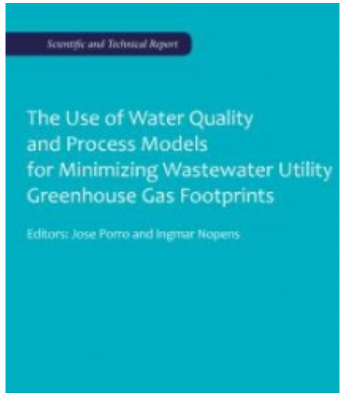
- WRRmod
- Watermatex



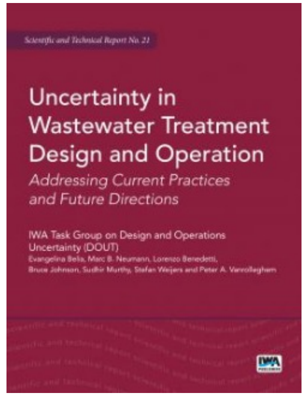
STR
(Sept. 2012)



STR
(Sept. 2014)



STR
(2021)



STR
(2021)

MIA SG: UPCOMING CONFERENCES

8th Water Resource Recovery Modelling seminar (WRRmod2023)

- Location: Stellenbosch, South Africa, January 2023
- Chair: Dr. David Ikumi (Univ. Cape Town)

11th Symposium on Modelling and Integrated Assessment (Watermatex2023)

- Location: Québec City, Canada, late summer 2023
- Chair/vice-chair: Prof. Peter Vanrolleghem (Univ. Laval)/Dr. Elena Torfs (Univ. Ghent)

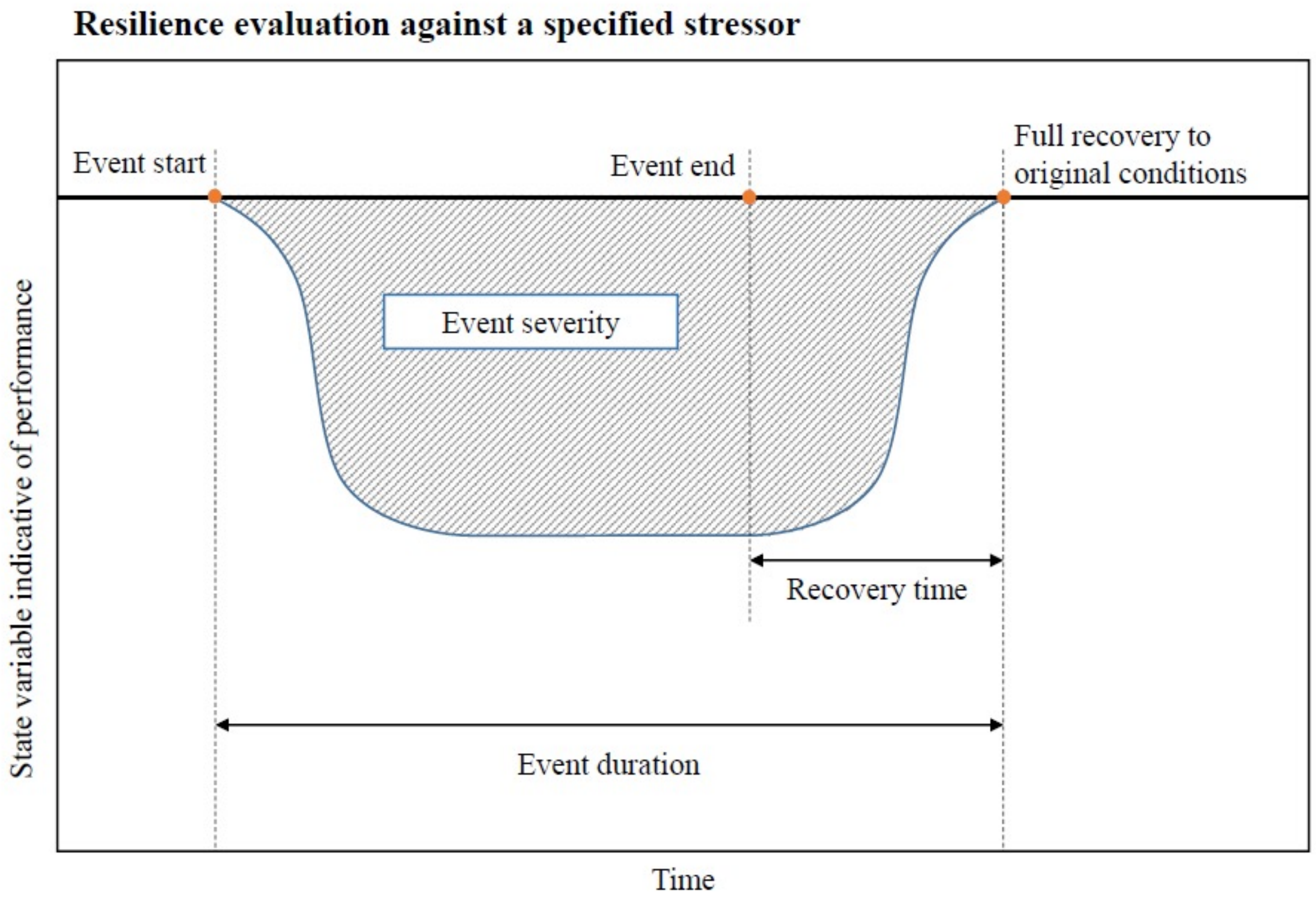
FIND MIA SG ON SOCIAL MEDIA

Follow the Modelling and Integrated Assessment Specialist Group on:

- IWA Connect – https://iwa-connect.org/group/modelling-and-integrated-assessment-mia/timeline
- https://www.linkedin.com/company/iwa-mia-specialist-group-on-modelling-and-integrated-assessment
- https://twitter.com/iwa_mia_sg
- **MIA SG open web site** http://iwa-mia.org

to get informed about our latest events, publications and news!

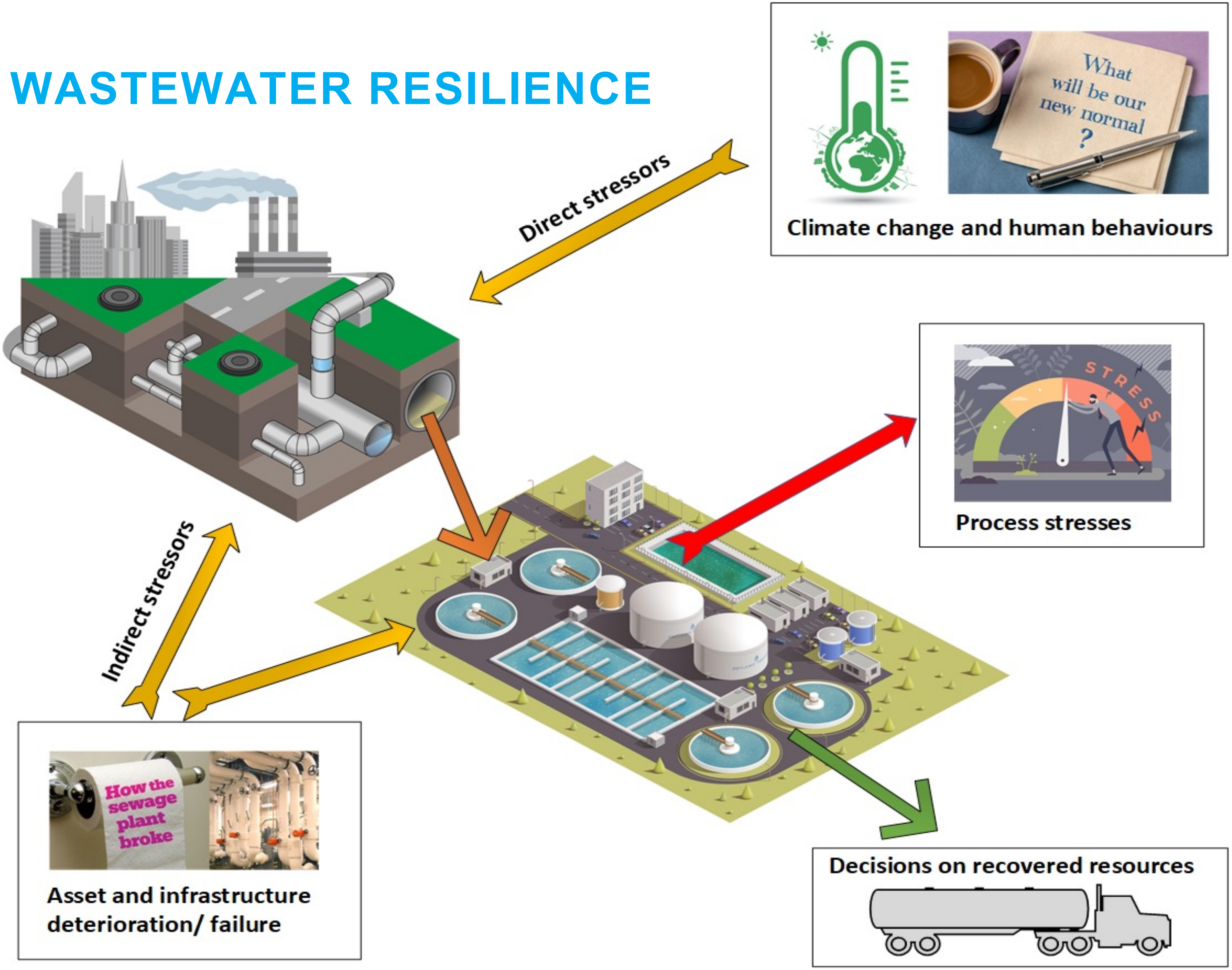
DEFINITION OF RESILIENCE



Resilience to a stressor presented by Juan-García, (2017) adapted from Mugume, (2015)

"Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same pre-disturbance process, form, identity, and feedbacks" (Walker et al., 2004)

WASTEWATER RESILIENCE



THEMES COVERED IN THIS WEBINAR

- The use of existing modelling practices to evaluate the dynamic resilience of wastewater treatment processes
- The challenge of visually communicating modelled outputs to operational staff
- The move toward general resilience assessment for urban wastewater systems
- The challenge of modelling decisions on optimal process streams for resource recovery

AGENDA AND HOUSEKEEPING

Speaker 1
Timothy Holloway (University of Portsmouth, UK)

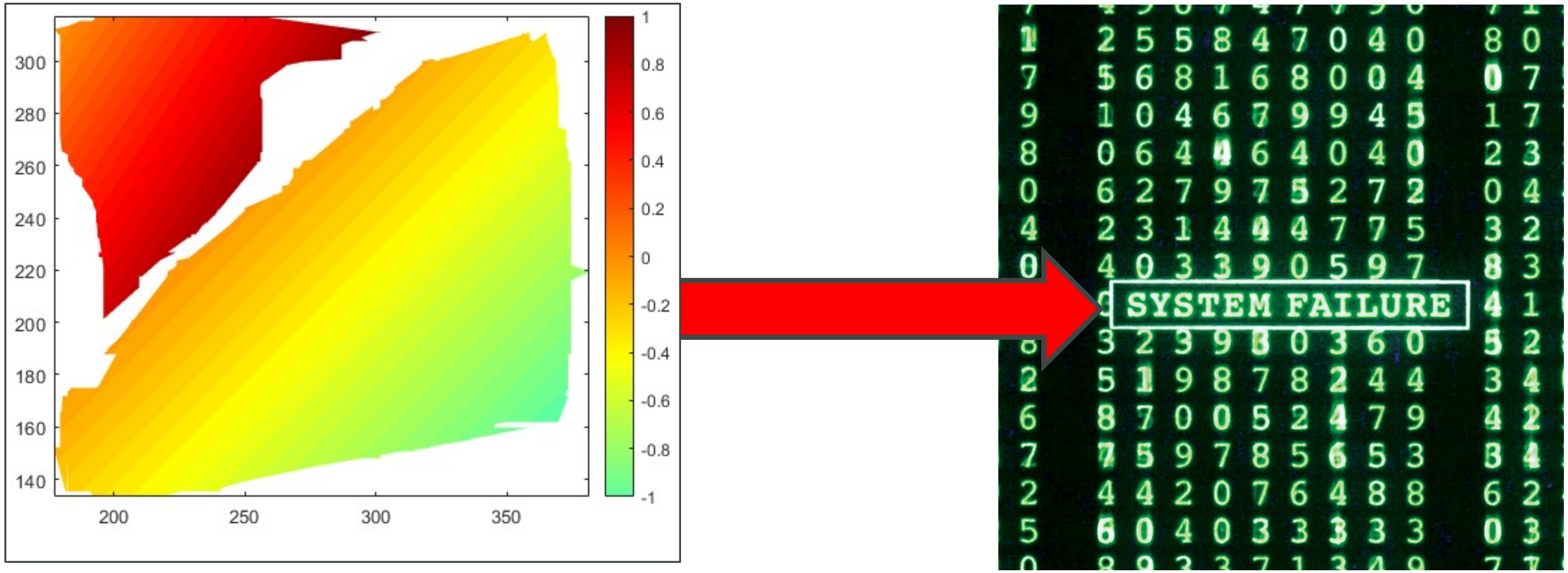
Speaker 2
Guangtao Fu (University of Exeter, UK)

Speaker 3
Seda Sucu (University of Portsmouth, UK)

Q&A Session Moderator: *Maria Molinos-Senante (Universidad Católica de Chile)*

- This session is being recorded;
- Microphones and cameras have been disabled due to the large number of attendees;
- The normal chat function is disabled;
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).

Coupling conventional modelling with resilience theory for improved operational decision making



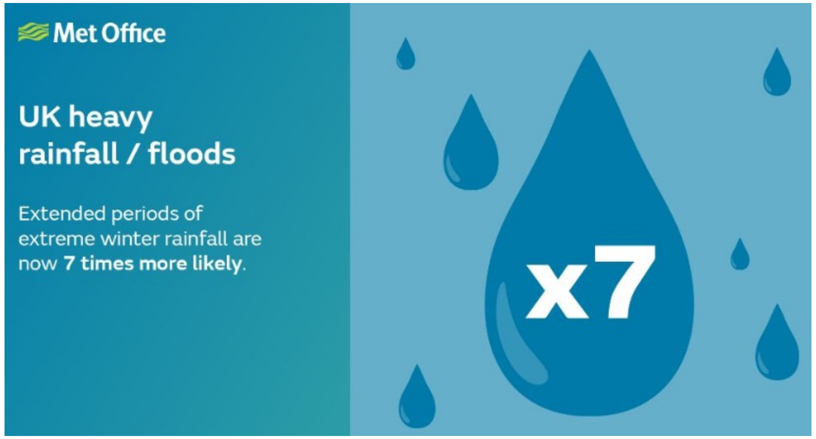
Timothy Holloway | Senior Scientific Officer
timothy.Holloway@port.ac.uk

PRESENTATION AGENDA

1. INTRODUCTION

Direct stressors

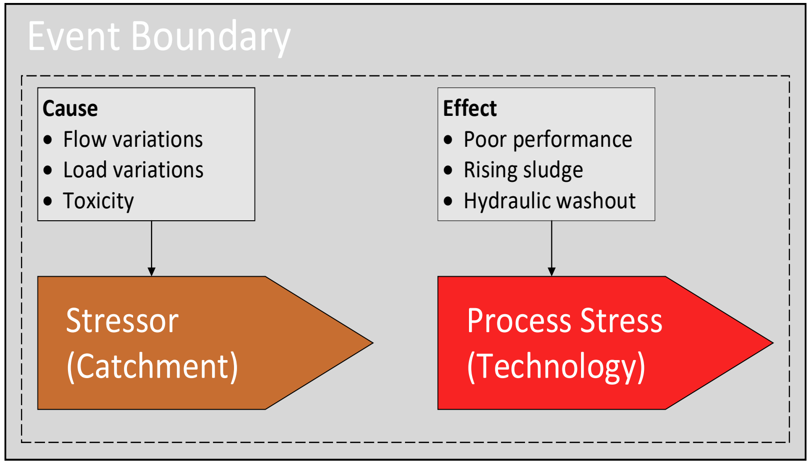
- Global population increase by 27% before the end of the century (OWID, 2019; UNEP, 2012). (**1.4 x planetary carrying capacity**)
- Dependent on our path temperatures could rise by > 2°C over pre- industrial levels (Masson-Delmotte, 2021)
- Rainfall intensity increased by 12 – 24 % (Fischer et al. 2014; Hansen et al. 2010)



(Met Office, 2017)

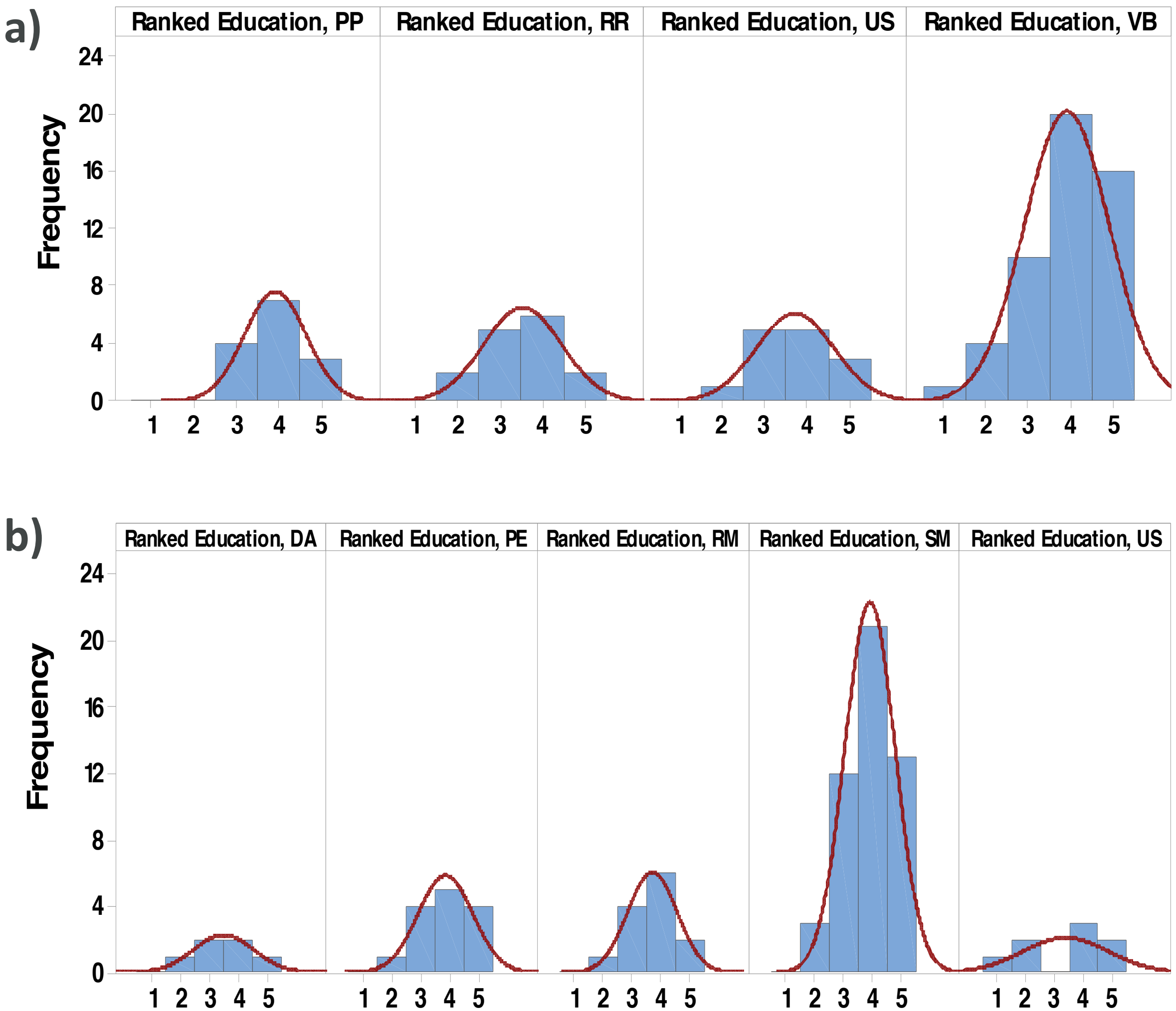
Impact on wastewater production

- Increase/reduction of municipal/industrial wastewaters with transient populations (COVID 19) (Kalbusch, 2020)
- Dilution of wastewaters during storm events
- Highly concentrated wastewaters in extended dry periods



Challenge: *stressors generating complex dynamic process stresses*

2. PROFESSIONAL SURVEY: PROCESS STRESS (EFFECT)



Holloway, T.G., Williams, J.B., Ouelhadj, D., Cleasby, B., 2019. Process stress in municipal wastewater treatment processes: a new model for monitoring resilience. Process Saf. Environ. Prot. 132, 169–181. https://doi.org/10.1016/j.psep.2019.09.032

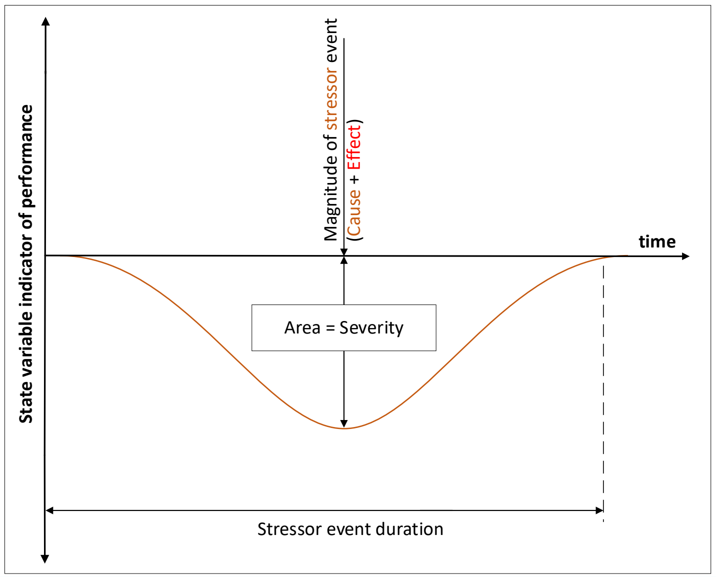
Survey of wastewater professionals (260)

a) Process stress the variance from benchmarked condition

b) Stress measurement was viewed as most important

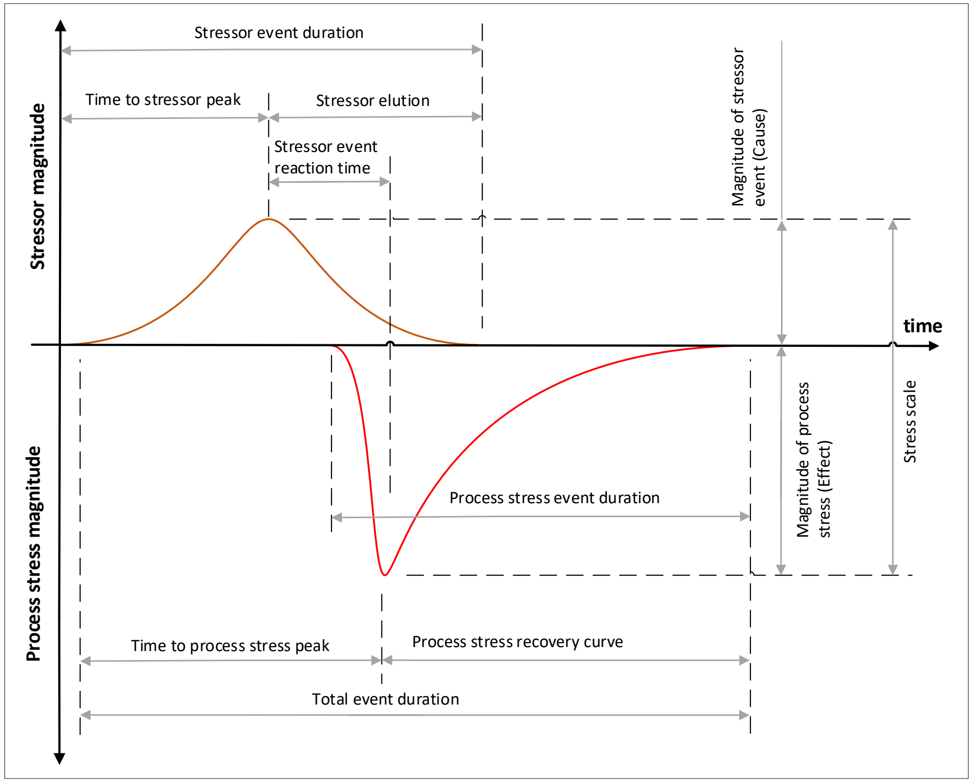
c) 82 % of respondents would use a tool for stress measurement

Stressors should be decoupled from process stresses

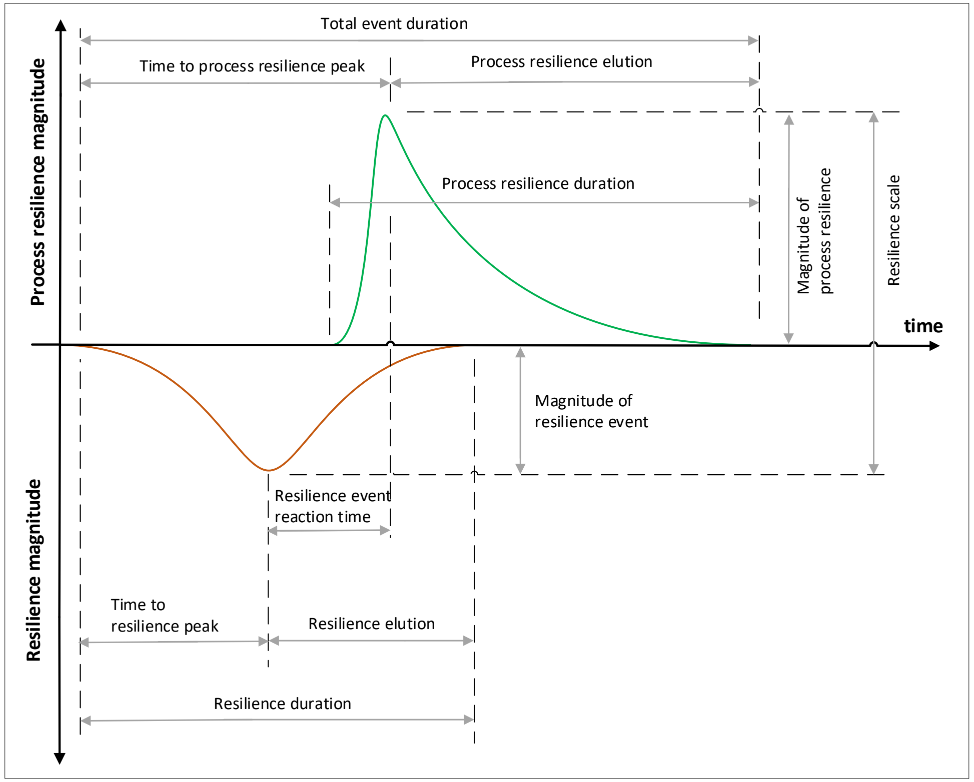


PROPOSED EXTENSION OF RESILIENCE METHODS

Stressor causing a process stress event



Stressor causing process relaxation

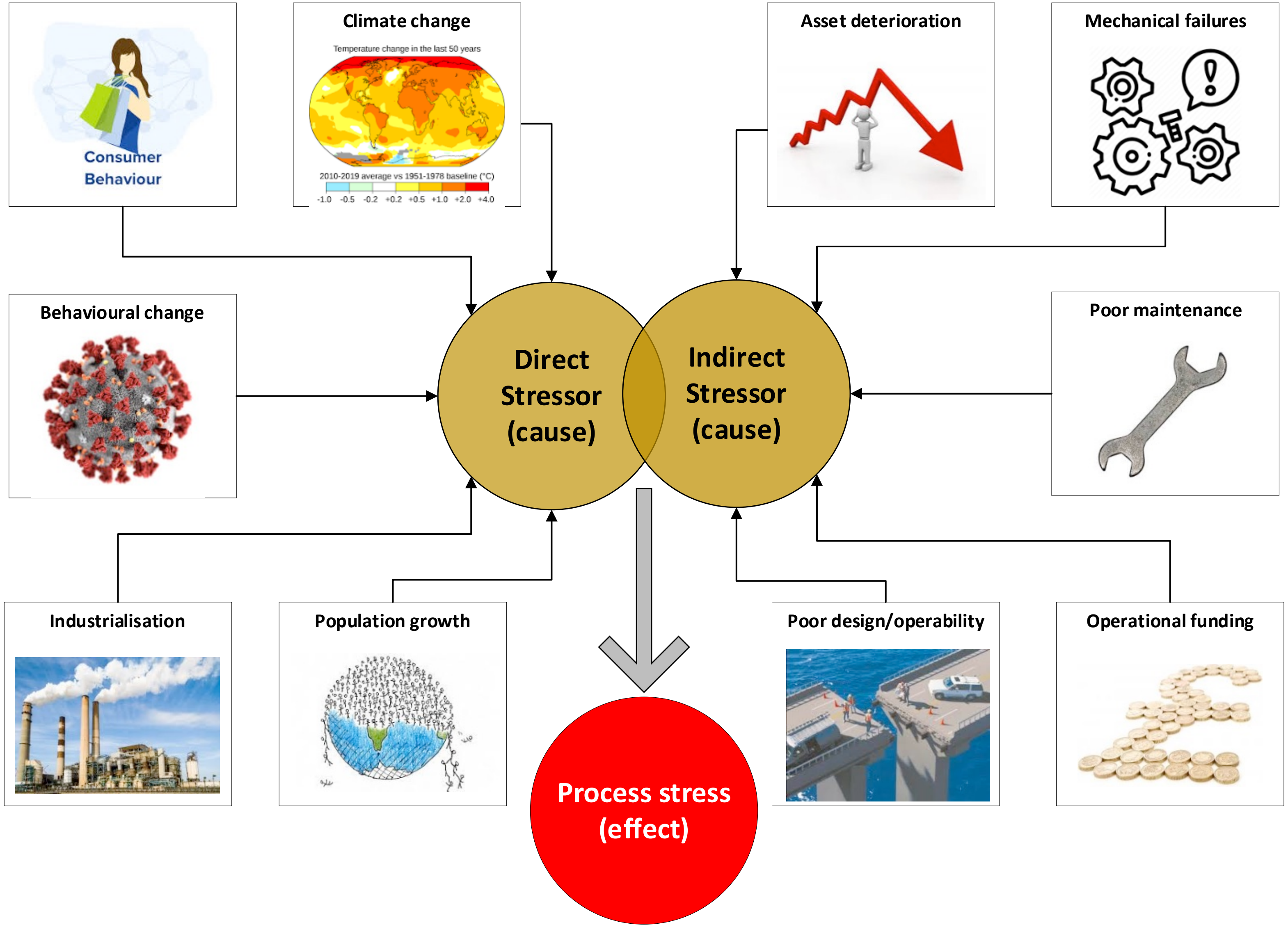


Proposed definition of dynamic resilience

"The dynamic, temporal variation of stressors and process stresses in response to events outside of the original design intent"

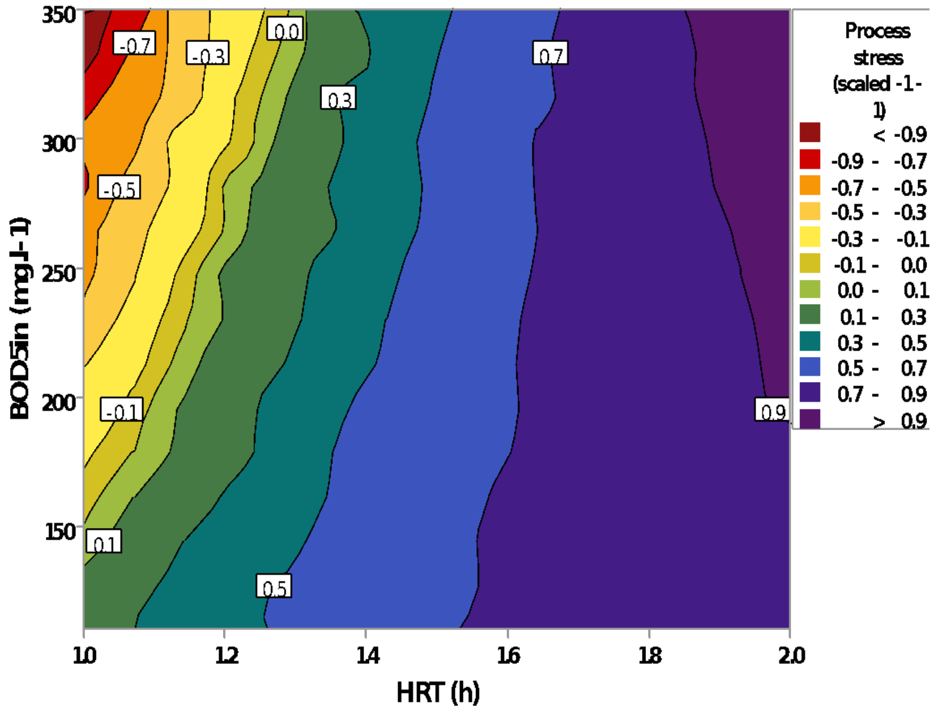
May be unavailable

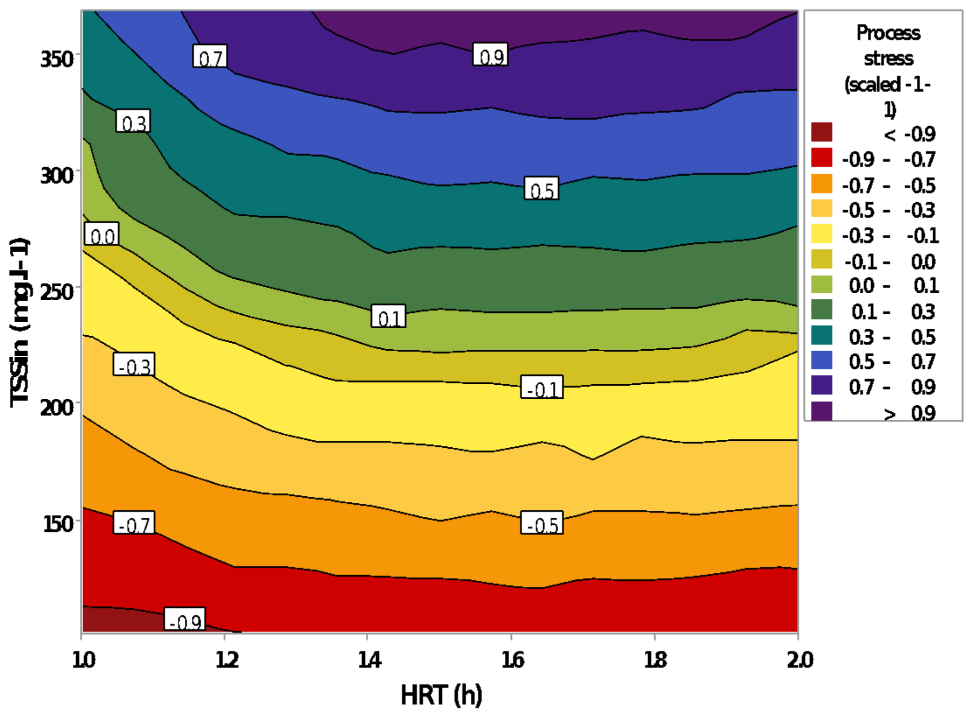
CONCEPTUAL BASIS FOR DYNAMIC RESILIENCE



"Stressors are the cause and process stress is the effect"

3. SCENARIO SIMULATIONS: PRIMARY SEDIMENTATION



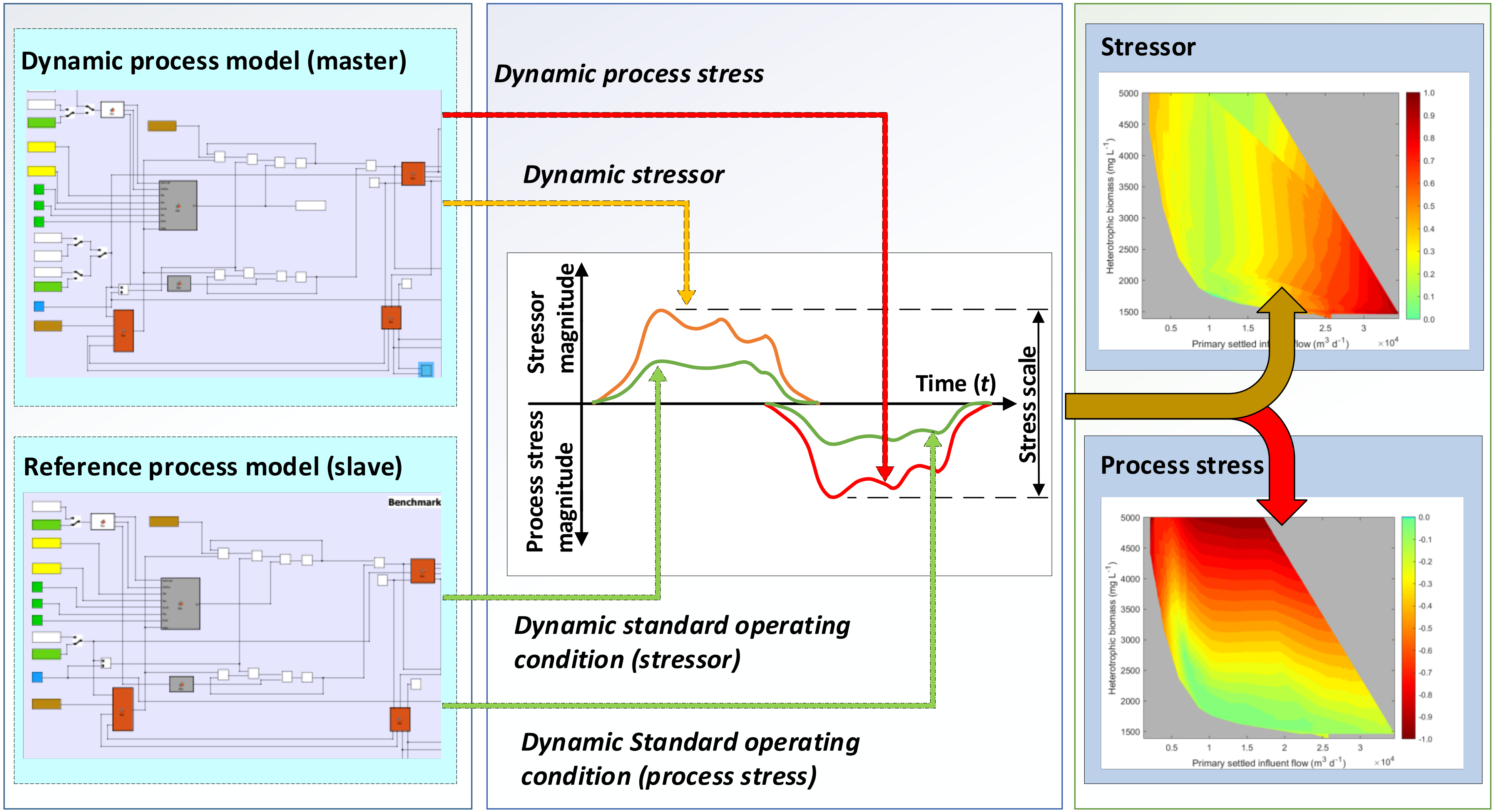


1. Monte-Carlo simulations for state simulation
2. Dynamic only by iteration (not based on actual data)
3. Follows the expected sedimentation outcomes

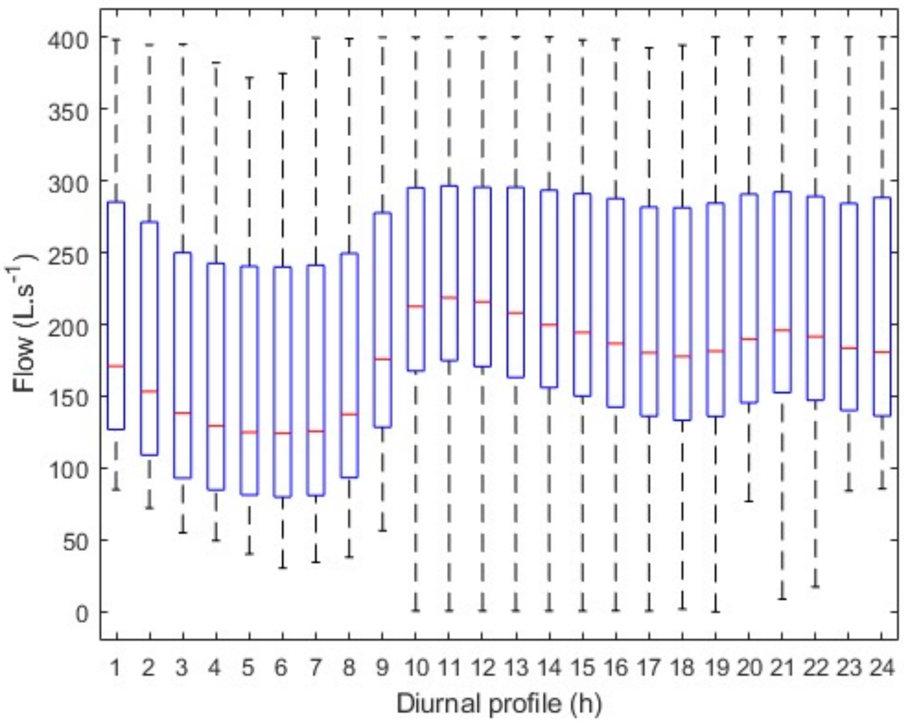
Holloway, T.G., Williams, J., Ouelhadj, D., Cleasby, B., 2021. Process stress, stability and resilience in wastewater treatment processes: a novel conceptual methodology. J. Clean. Prod. 282, 124434. https://doi.org/10.1016/j.jclepro.2020.124434

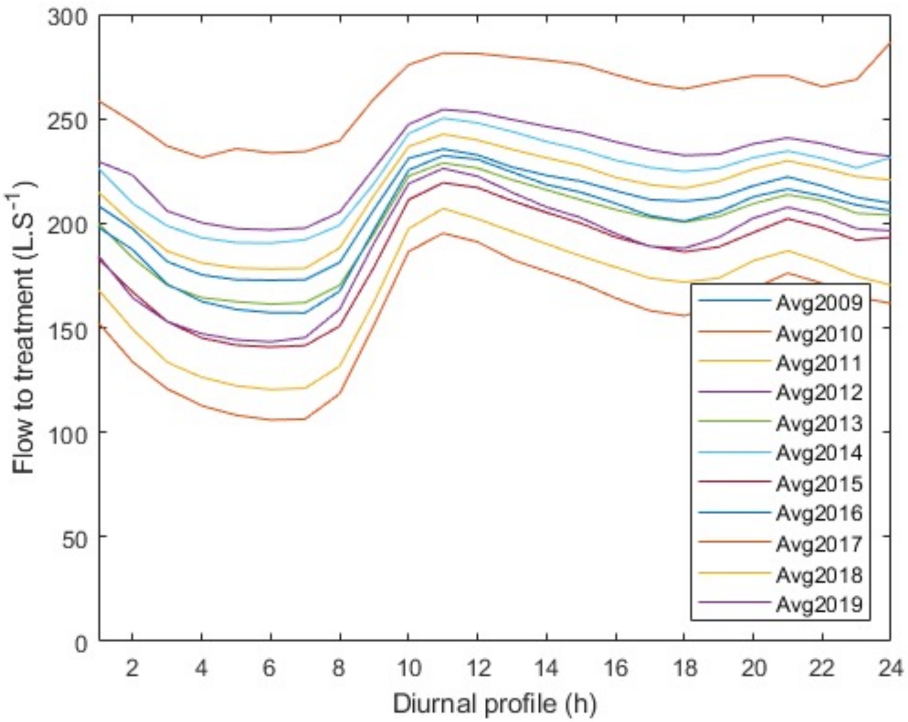
4. DATA DRIVEN DYNAMIC RESILIENCE ANALYSIS: ACTIVATED SLUDGE

1) Modelling	2) Computation of dynamic resilience	3) Self Ordering Windows

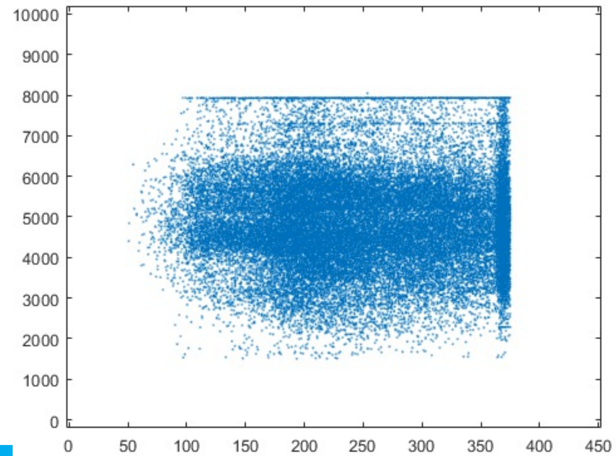


THE CHALLENGE OF REAL DATA



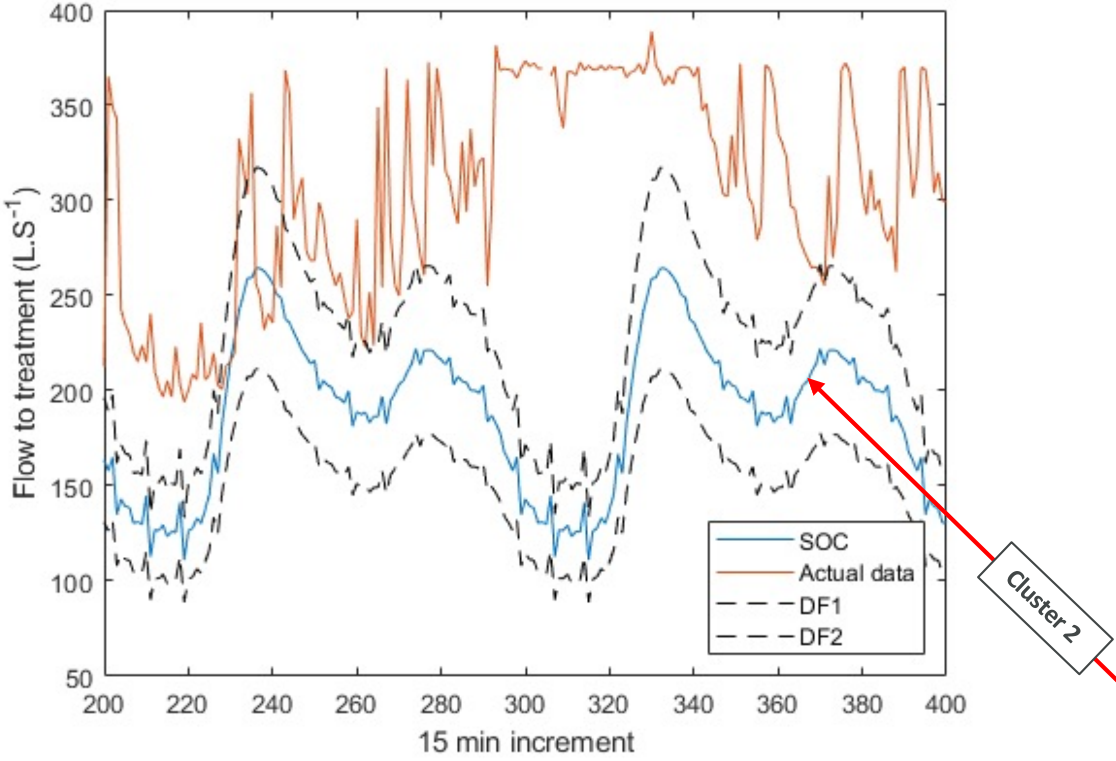


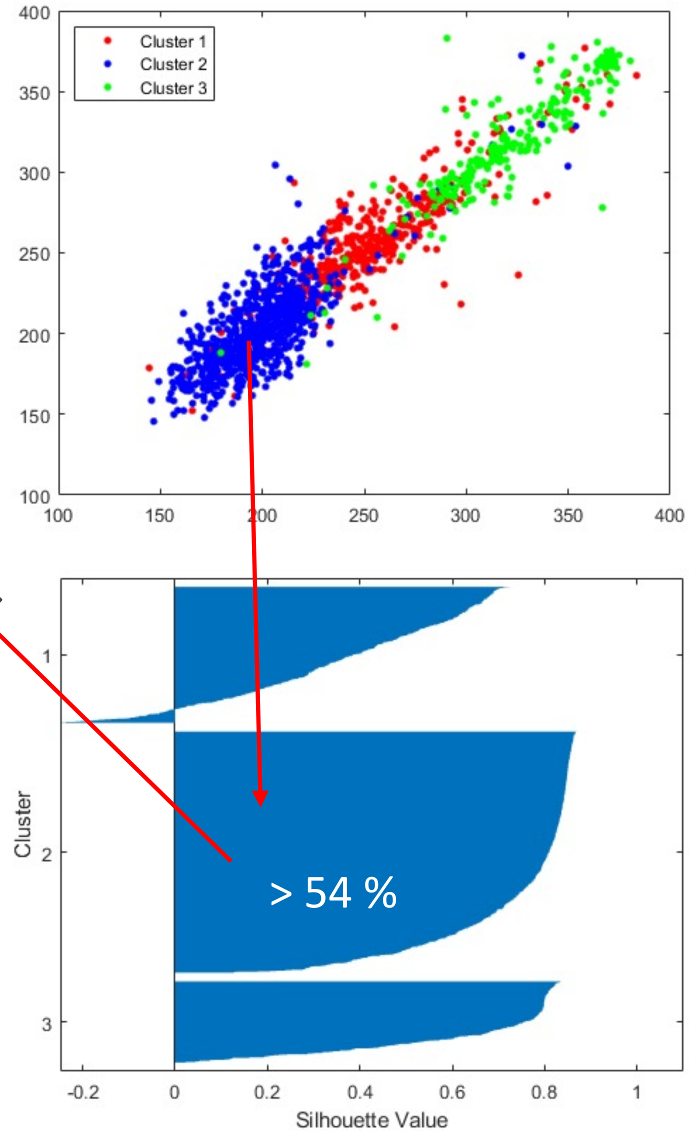
1. Average not representative (skewed central tendency)
2. Non-normal (or lognormal) distributions a challenge for off the shelf algorithms
3. Skewed data occurs due to inconsistencies, storm flows and calibration



But what can we learn from this?

OPERATING CONDITION EXTRACTION

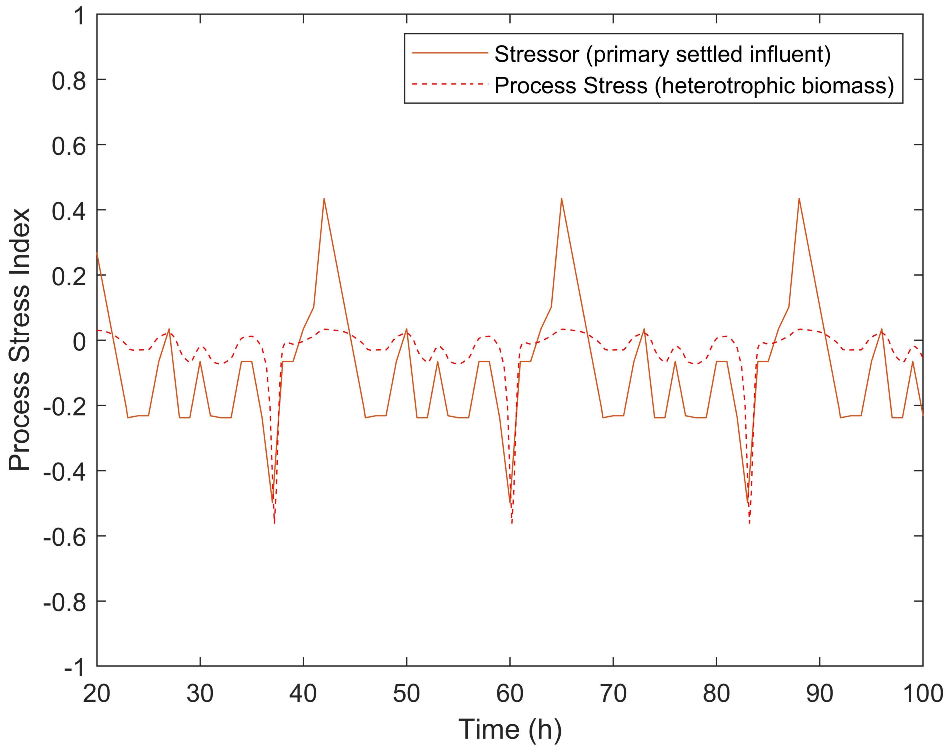




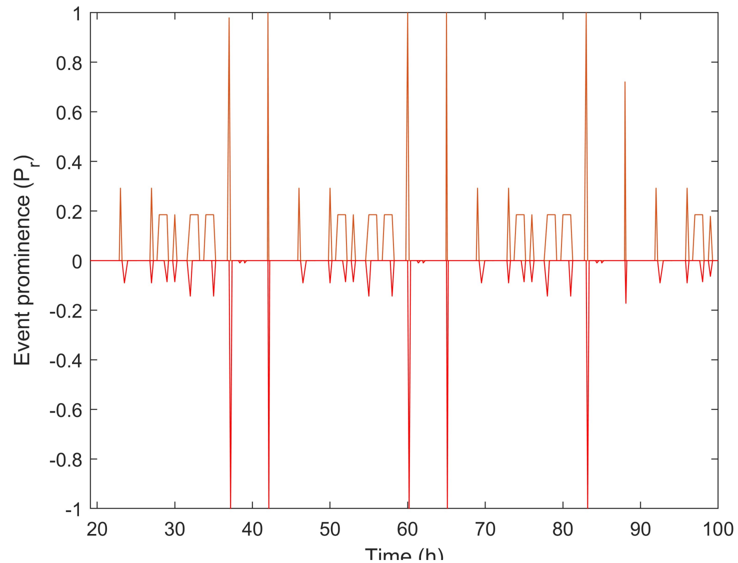
1. Data cleaning/validation required for outliers, along with restoration

2. Clustering performed to separate flow conditions

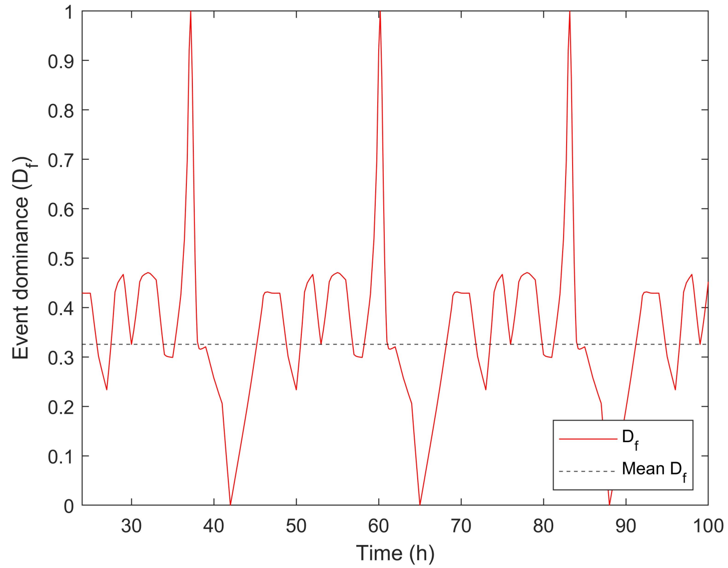
TIME BASED EVALUATION OF STRESSORS AND PROCESS STRESSES



Evaluate prominence



Evaluate dominance



Descriptive parameters

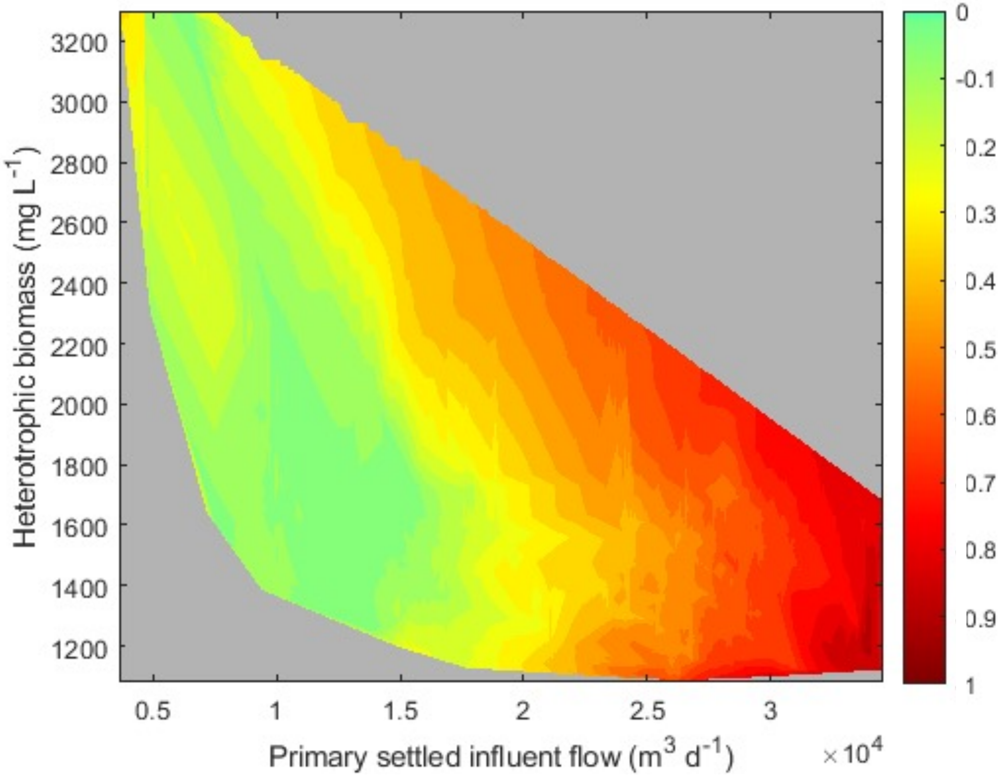
Probability of process failure ***pF***

Event prominence (***P_r***): evidence of event magnitude

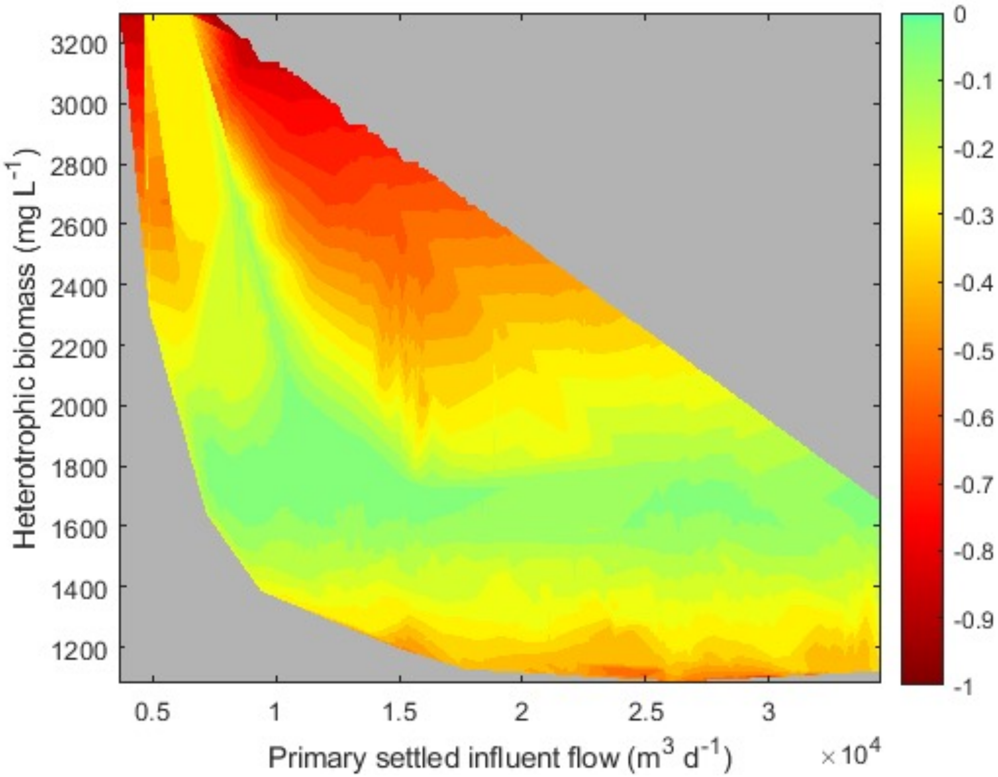
Event dominance (***D_f***): indication that prominent events are becoming more dominant

DYNAMIC RESILIENCE FROM SELF ORDERING WINDOWS

1) Self ordering window for stressor (flow)



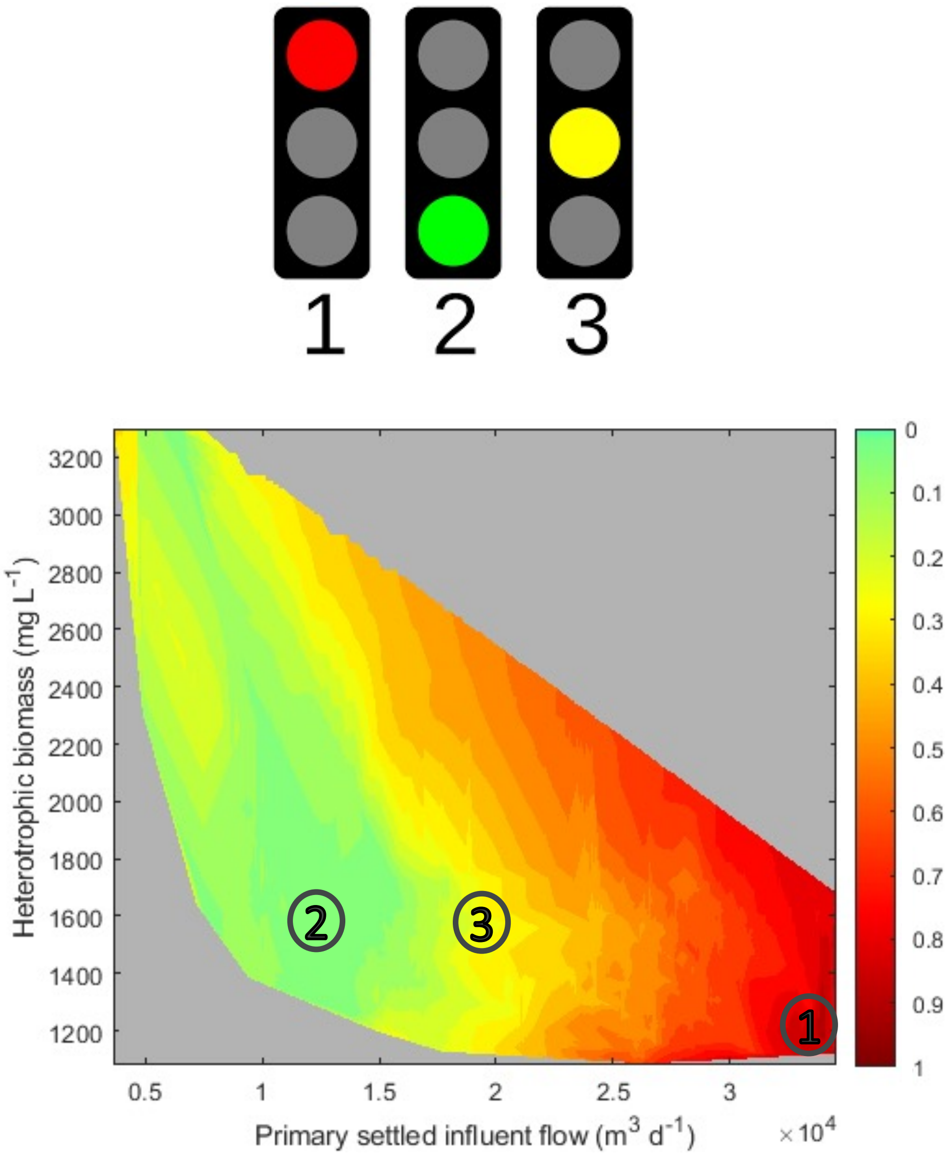
2) Self ordering window for process stress (biomass)

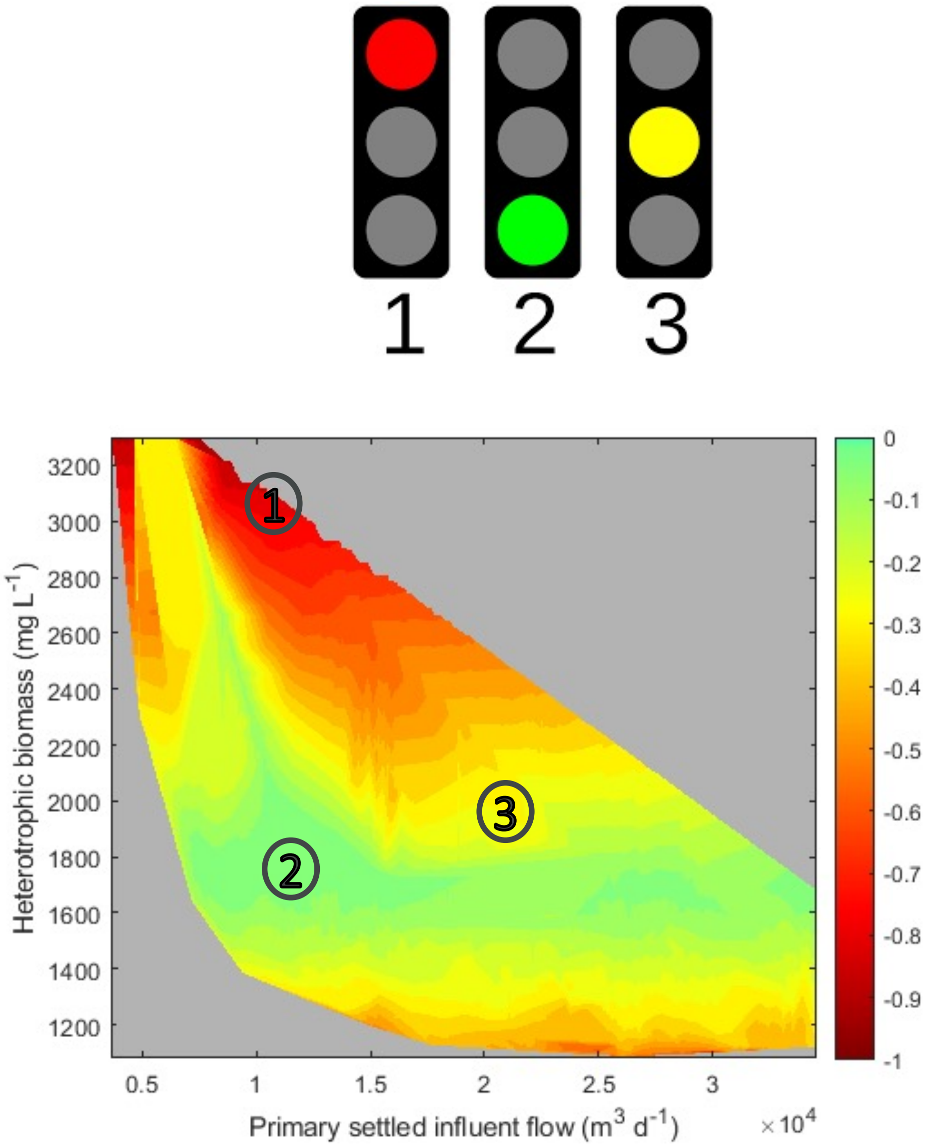


"Like a fingerprint, actual instrument data has been visualised to generate process knowledge"

Holloway, T., Williams, J.B., Ouelhadj, D., Yang, G., 2021. Dynamic resilience for biological wastewater treatment processes: Interpreting data for process management and the potential for knowledge discovery. J. Water Process Eng. 42, 102170. https://doi.org/10.1016/j.jwpe.2021.102170

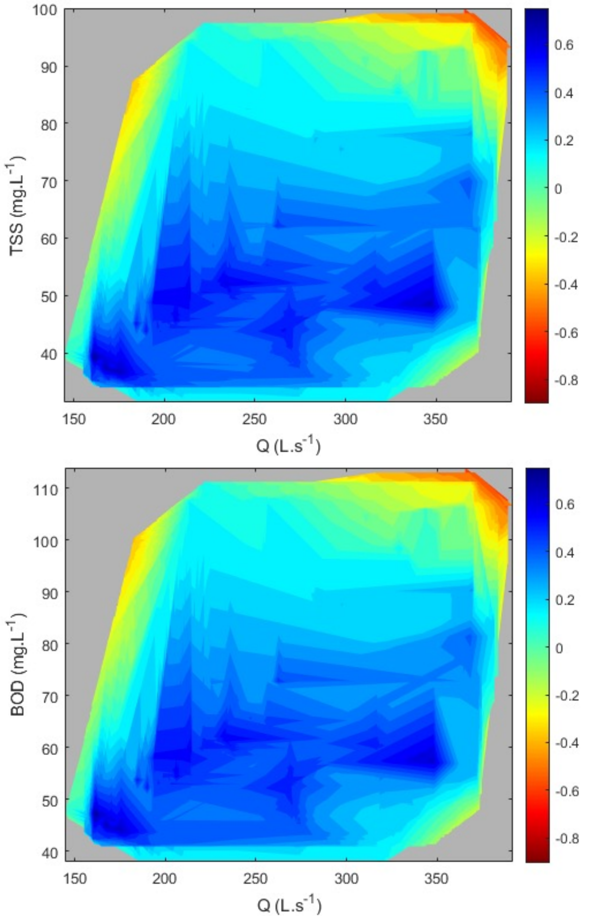
OPERATOR COMMUNICATION





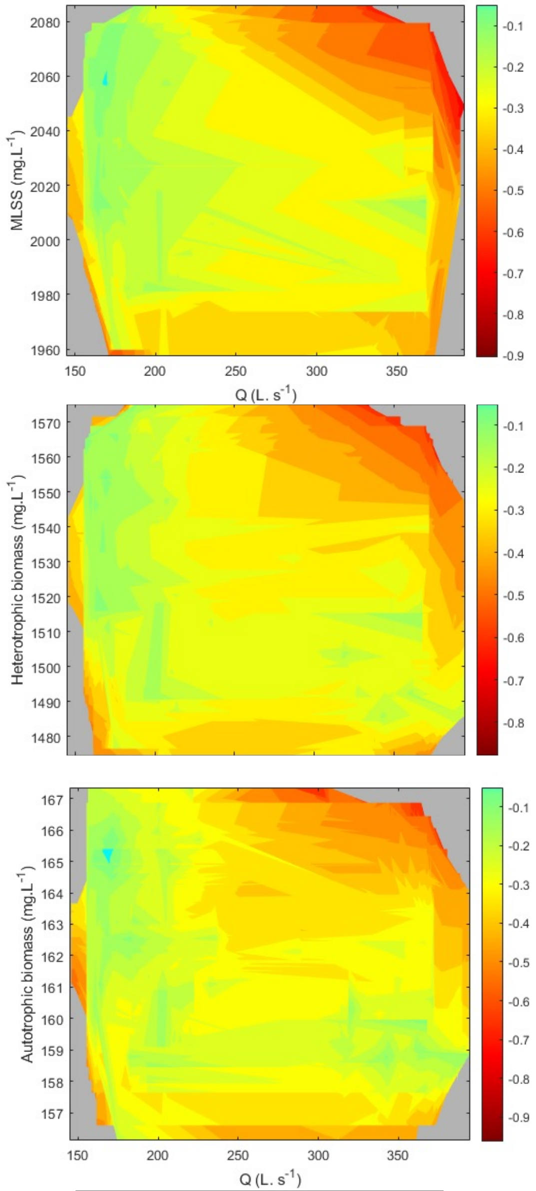
DYNAMIC RESILIENCE OF AN ENTIRE PLANT: NEXT STEPS

Process stresses
Primary sedimentation



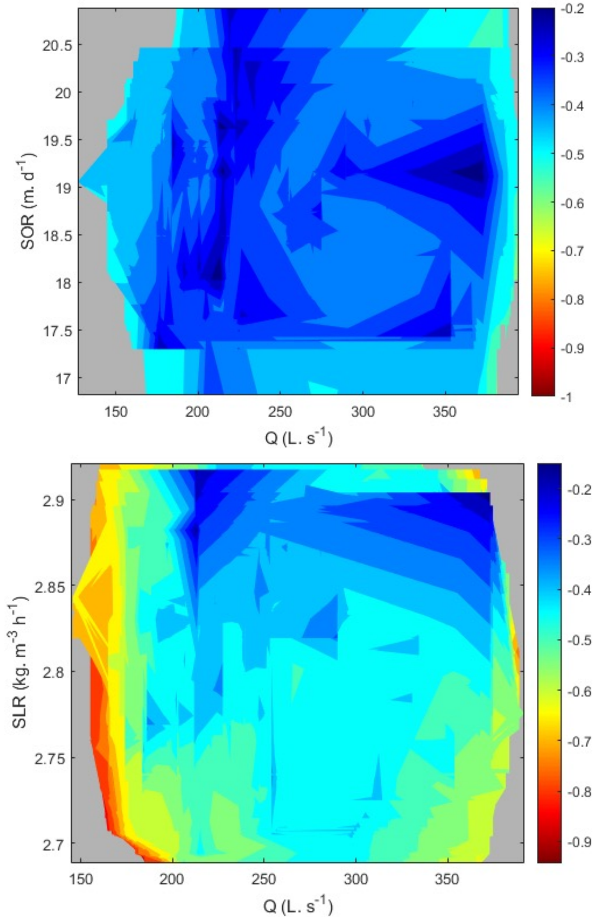
PSI scale -1 to1

Process stresses
Activated sludge



PSI scale -1 to 0

Process stresses
Humus settlement



PSI scale -1 to1

5. CONCLUSIONS

- Dynamic resilience of wastewater assets requires separation of stressors from process stresses

- It has been possible to use actual instrument data to simulate and visualise stressors and process stresses

- Dynamic stressors have been identified from the data and used to simulate process stresses

Get involved with our survey:

https://www.surveymonkey.co.uk/r/33FQ9BQ

AGENDA AND HOUSEKEEPING

Speaker 1
Timothy Holloway (University of Portsmouth, UK)

Speaker 2
Guangtao Fu (University of Exeter, UK)

Speaker 3
Seda Sucu (University of Portsmouth, UK)

Q&A Session moderator: *Maria Molinos-Senante (Universidad Católica de Chile)*

- This session is being recorded;
- Microphones and cameras have been disabled due to the large number of attendees;
- The normal chat function is disabled;
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).

IWA Specialist Group on Modelling and Integrated Assessment Webinar Series 21/10/2021

Towards general resilience assessment of urban wastewater systems

Guangtao Fu

Professor of Water Intelligence
Turing Fellow, Alan Turing Institute

UNIVERSITY OF EXETER

Safe&SuRe Water management

Definitions

Specified resilience: *"the resilience of some particular part of the system… to one or more identified kinds of shocks"* *(Folke et al. 2010)*

What about trade-offs?

What about the unknowns?

General resilience: *"the resilience of any and all parts of a system to all kind of shocks including novel ones"* *(Folke et al. 2010)*

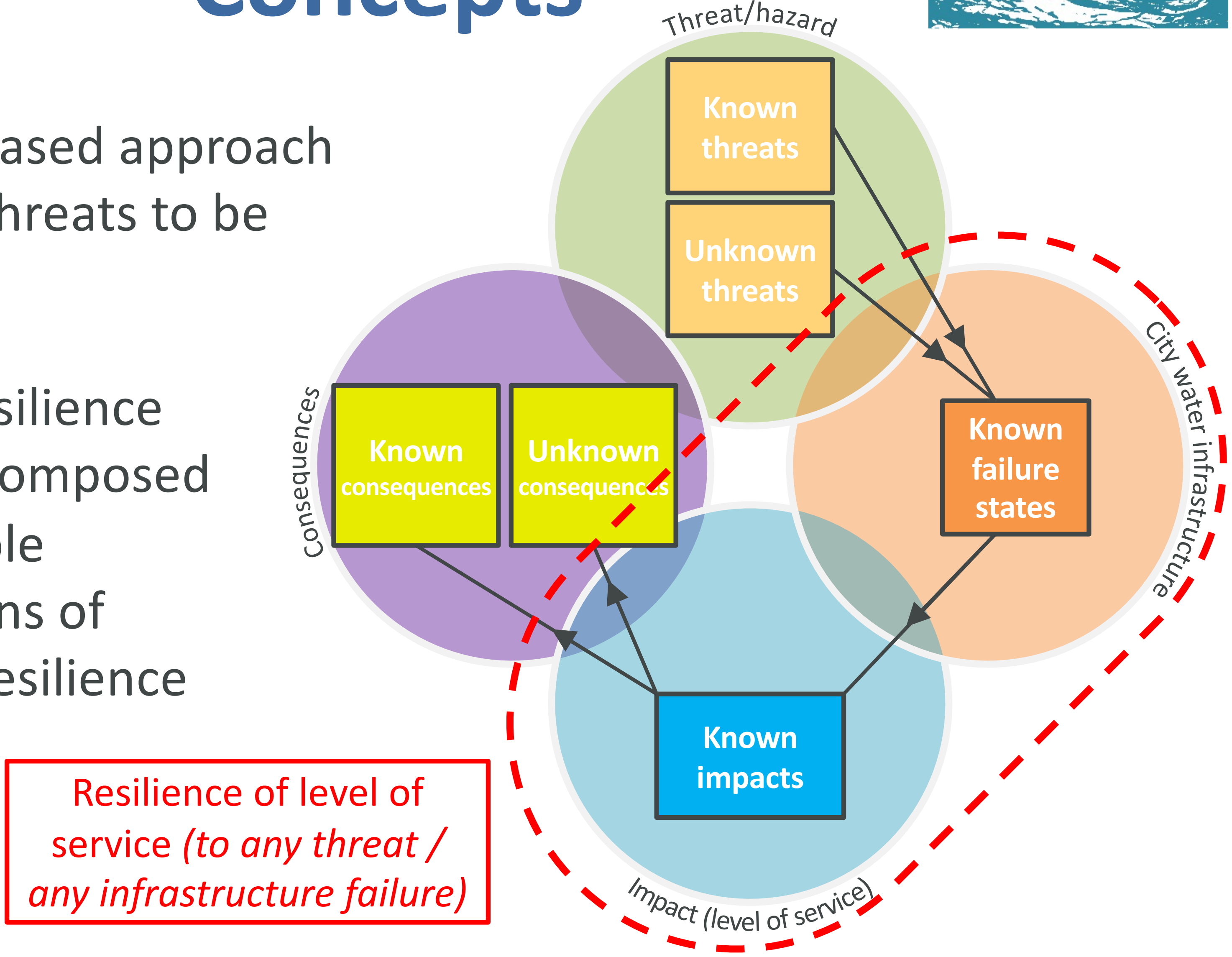
- Assessment challenging
- Typically qualitative or property-based

AIM: ***To provide a quantitative assessment approach of general resilience which is based on system performance***

Concepts

1. A middle based approach allows all threats to be addressed

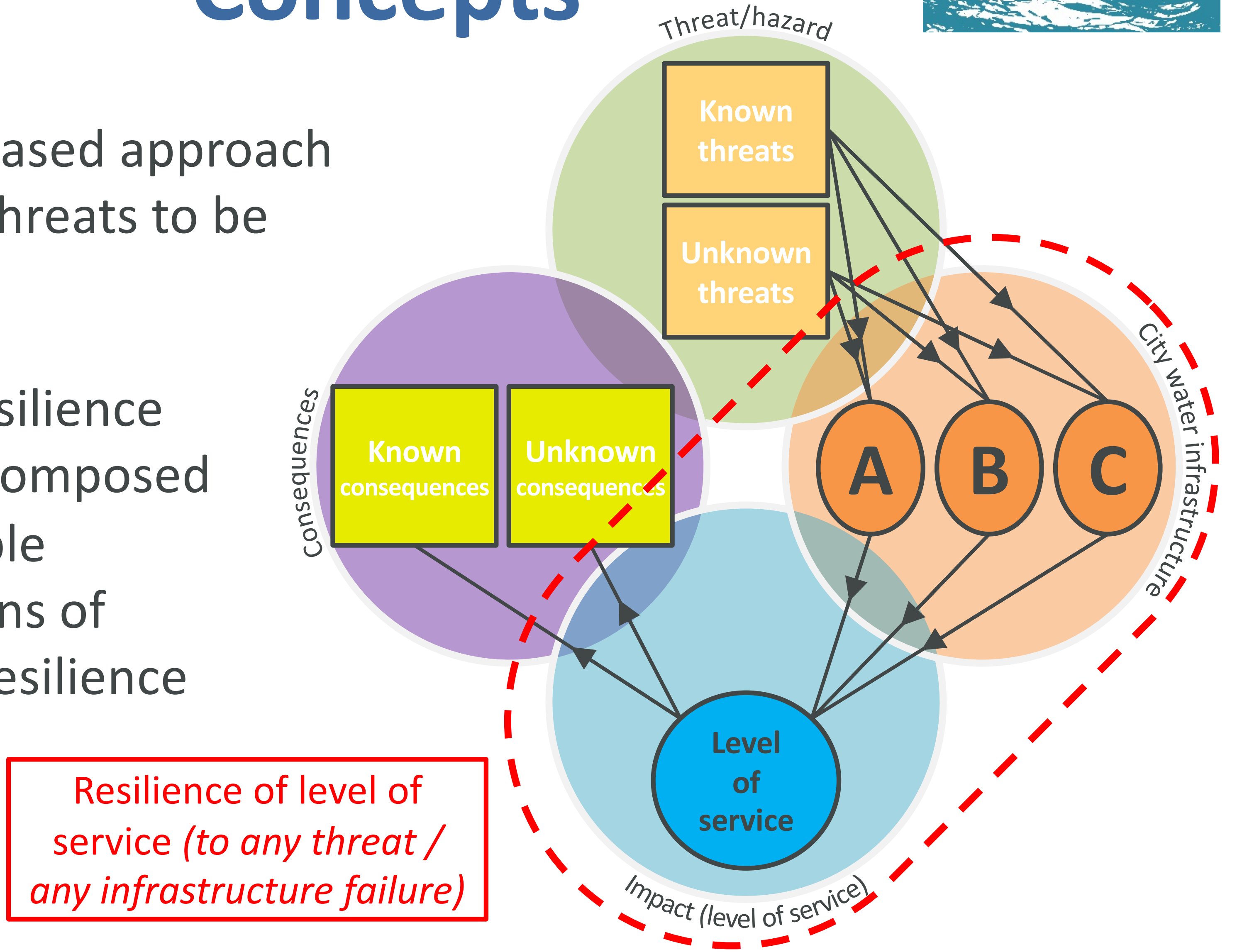
2. General resilience can be decomposed into multiple formulations of specified resilience

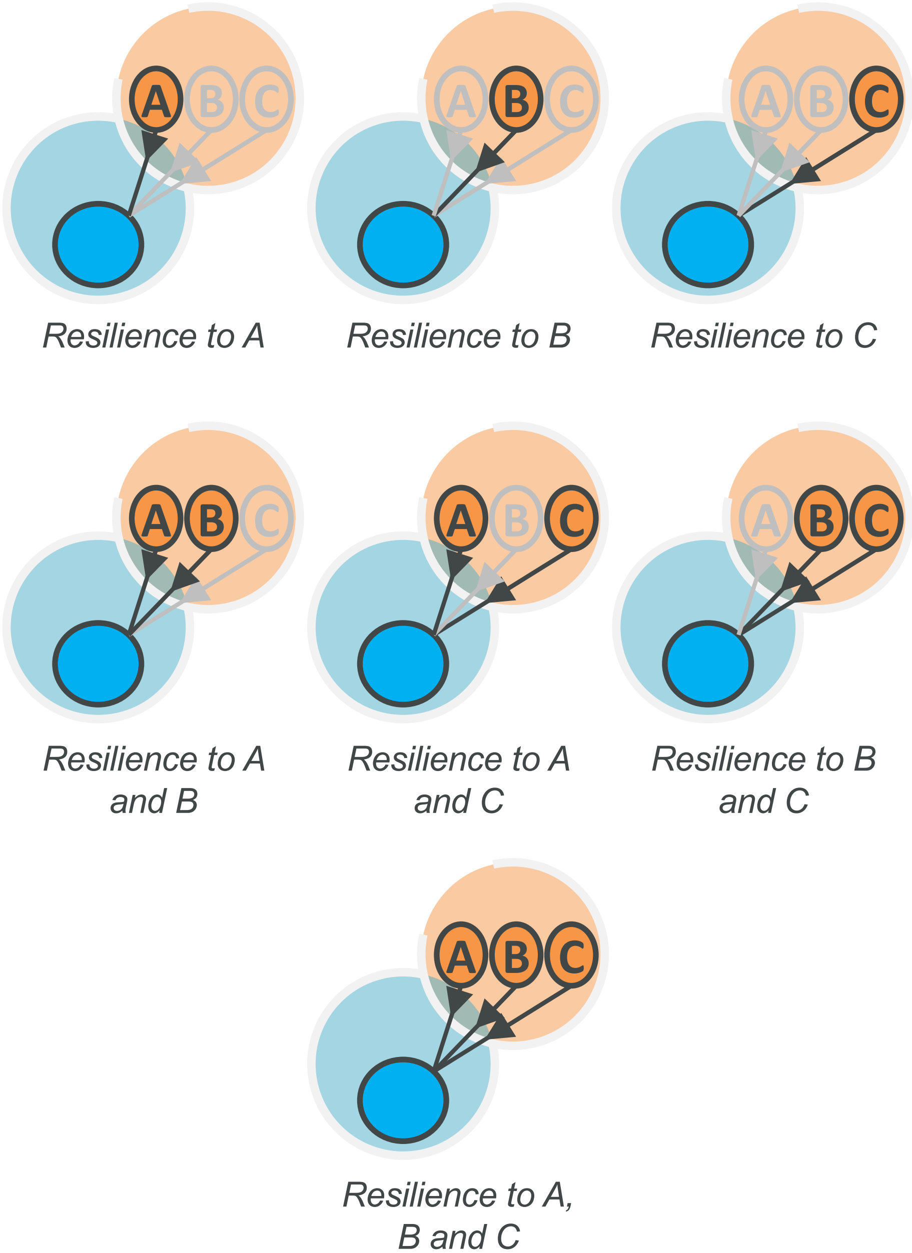


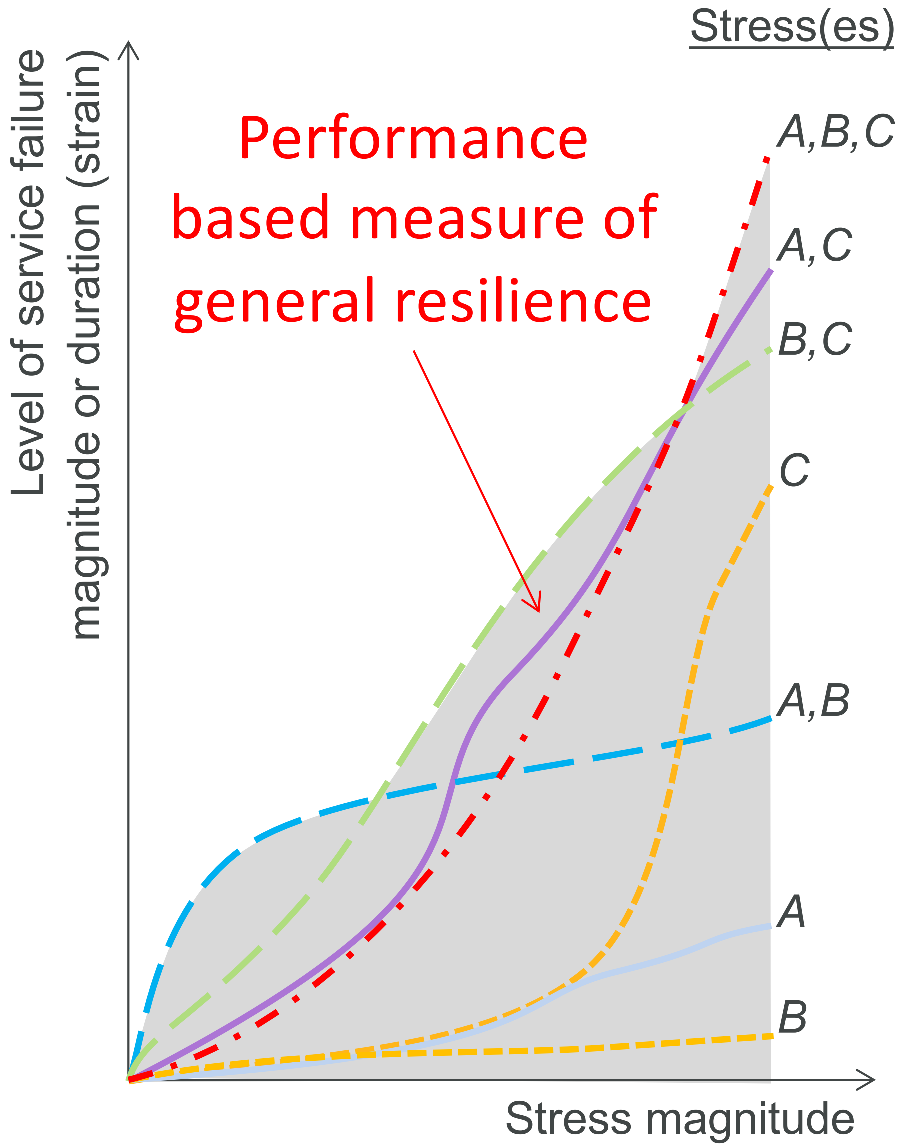
Concepts

1. A middle based approach allows all threats to be addressed

2. General resilience can be decomposed into multiple formulations of specified resilience

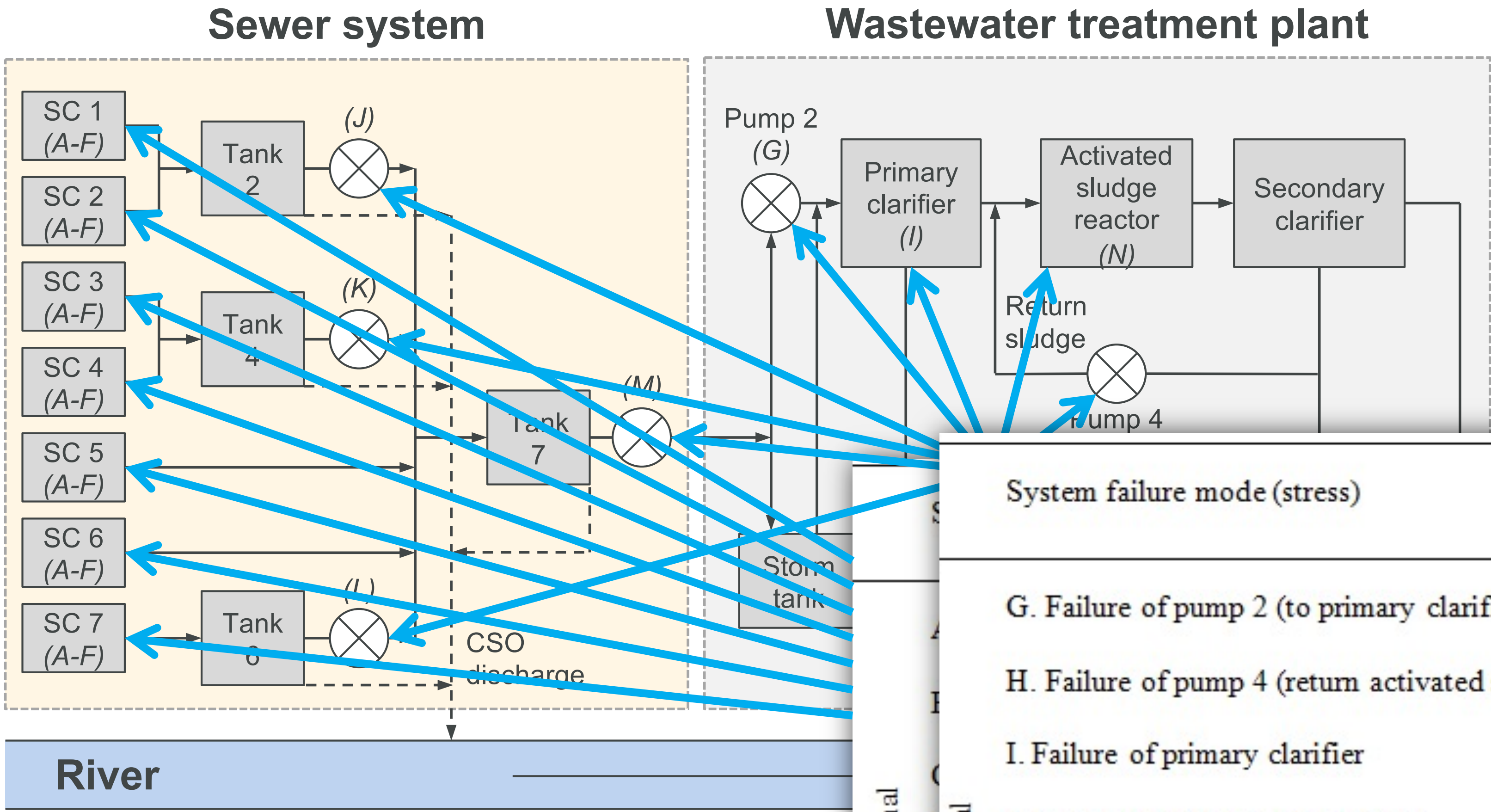



A B C
Resilience to A
Resilience to B
Resilience to C
Resilience to A and B
Resilience to A and C
Resilience to B and C
Resilience to A, B and C


Stress(es)
Level of service failure magnitude or duration (strain)
Performance based measure of general resilience
A,B,C
A,C
B,C
C
A,B
A
B
Stress magnitude

STEP 1: *Identify all system failure modes*

Integrated urban wastewater system case study



	System failure mode (stress)
Internal	G. Failure of pump 2 (to primary clarifier)
	H. Failure of pump 4 (return activated sludge)
	I. Failure of primary clarifier
	J. Failure of tank 2 outflow pump
	K. Failure of tank 4 outflow pump
	L. Failure of tank 6 outflow pump
	M. Failure of tank 7 outflow pump
	N. Failure of activated sludge aeration

External

STEP 2: *Identify all impacts*

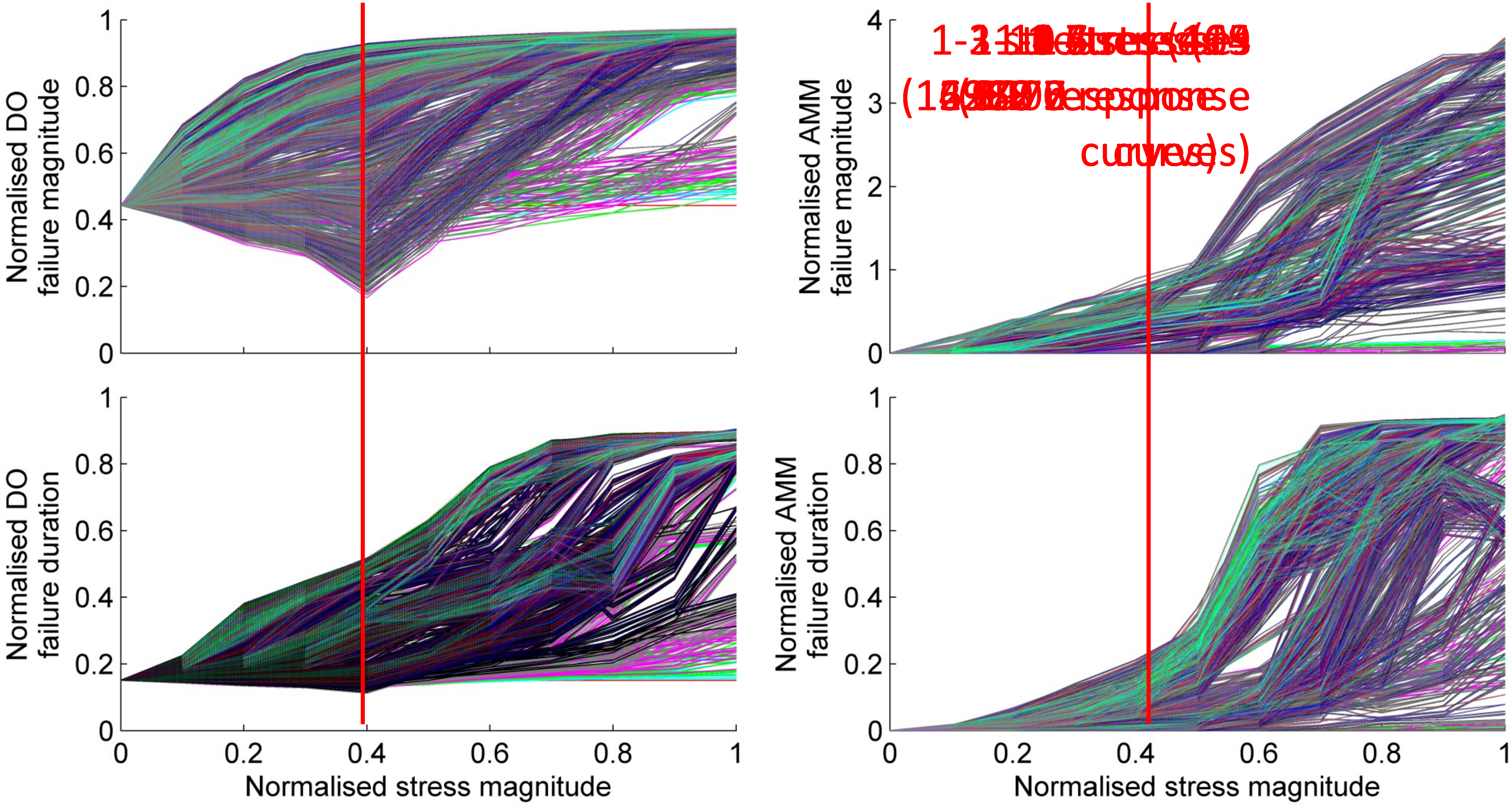
Impacts	Measures of strain
1. Receiving water **DO concentration** *(<4mg/l constitutes failure)*	Normalised DO failure magnitude
	Normalised DO failure duration
2. Receiving water **un-ionised ammonia concentration** *(>0.068mg/l constitutes failure)*	Normalised AMM failure magnitude
	Normalised AMM failure duration

STEP 3: *Generate impact / failure mode combinations*

Number of stresses applied	Number of combinations	Number of stresses applied	Number of combinations	Number of stresses applied	Number of combinations
1	14	6	3003	11	364
2	91	7	3432	12	91
3	364	8	3003	13	14
4	1001	9	2002	14	1
5	2002	10	1001		

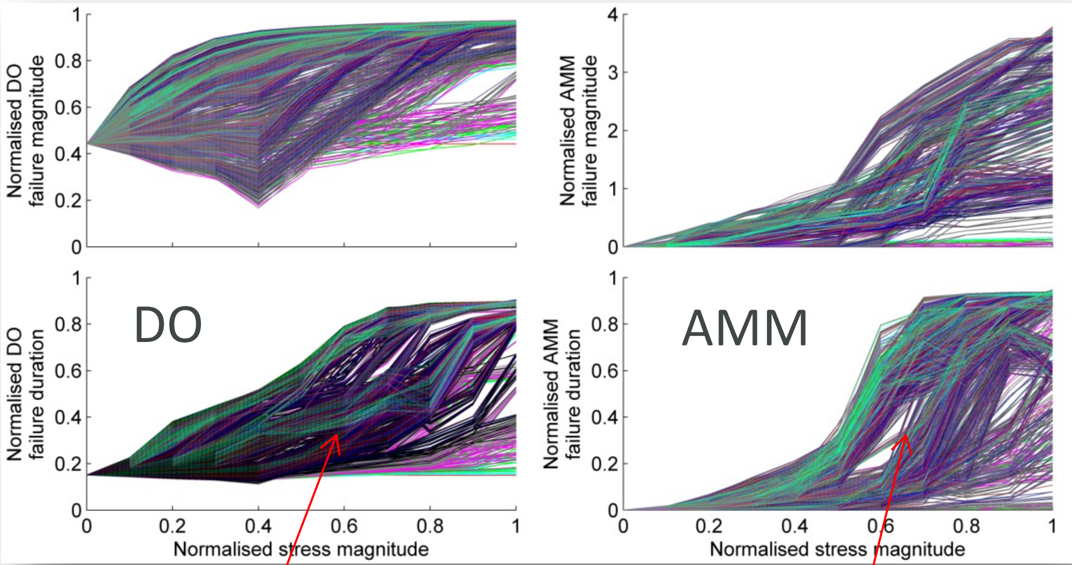
<u>TOTAL:</u> 16,383 system failure mode combinations

STEP 4: *Specified resilience assessment for each impact / failure mode combination*



Interventions development

STEP 1: Identify priority level of service measures

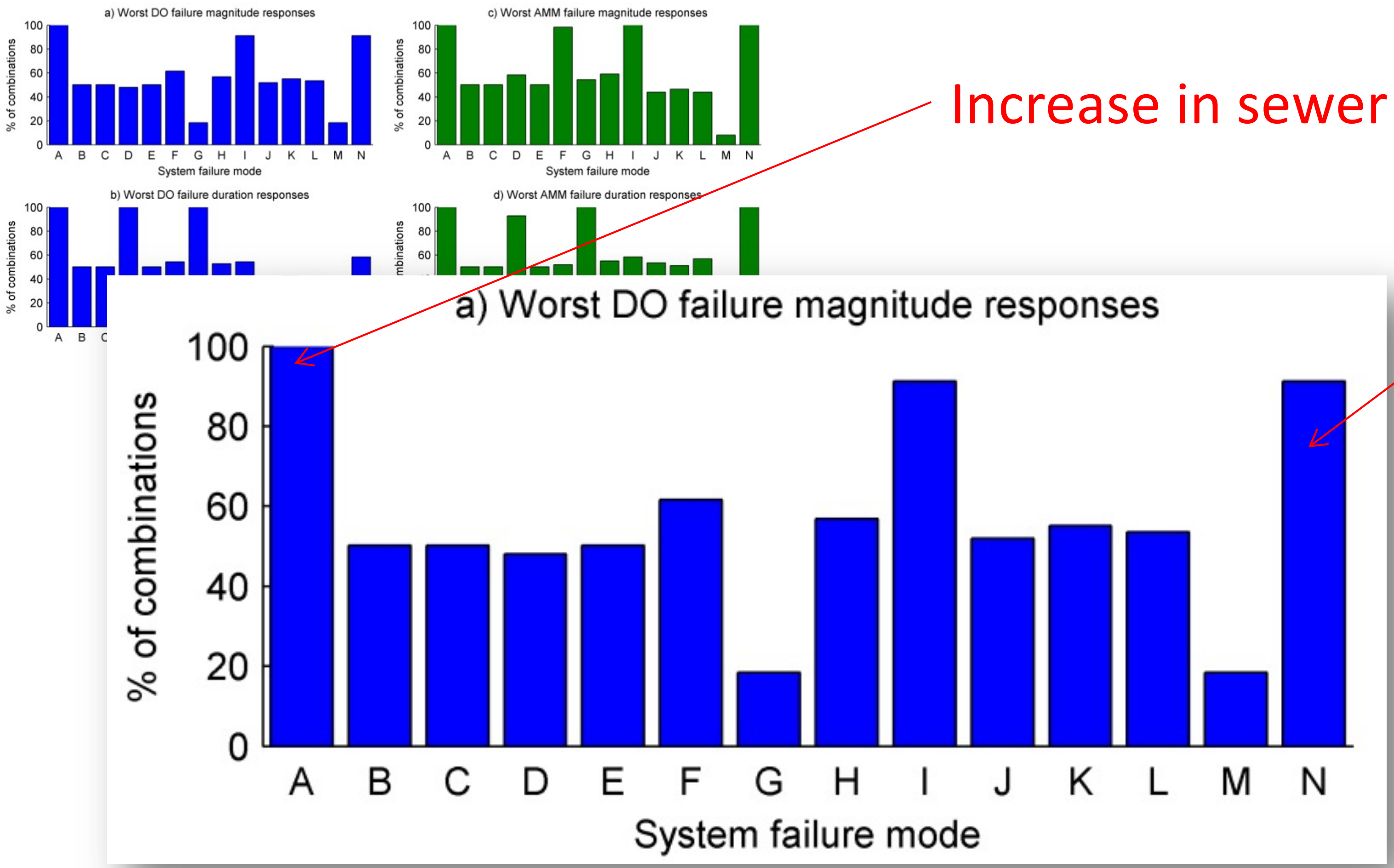


Area = 0.62

Area = 0.46

- DO level less resilient than AMM, based on failure duration
- Reduce DO failures when no system failures

STEP 2: Identify priority system failure modes



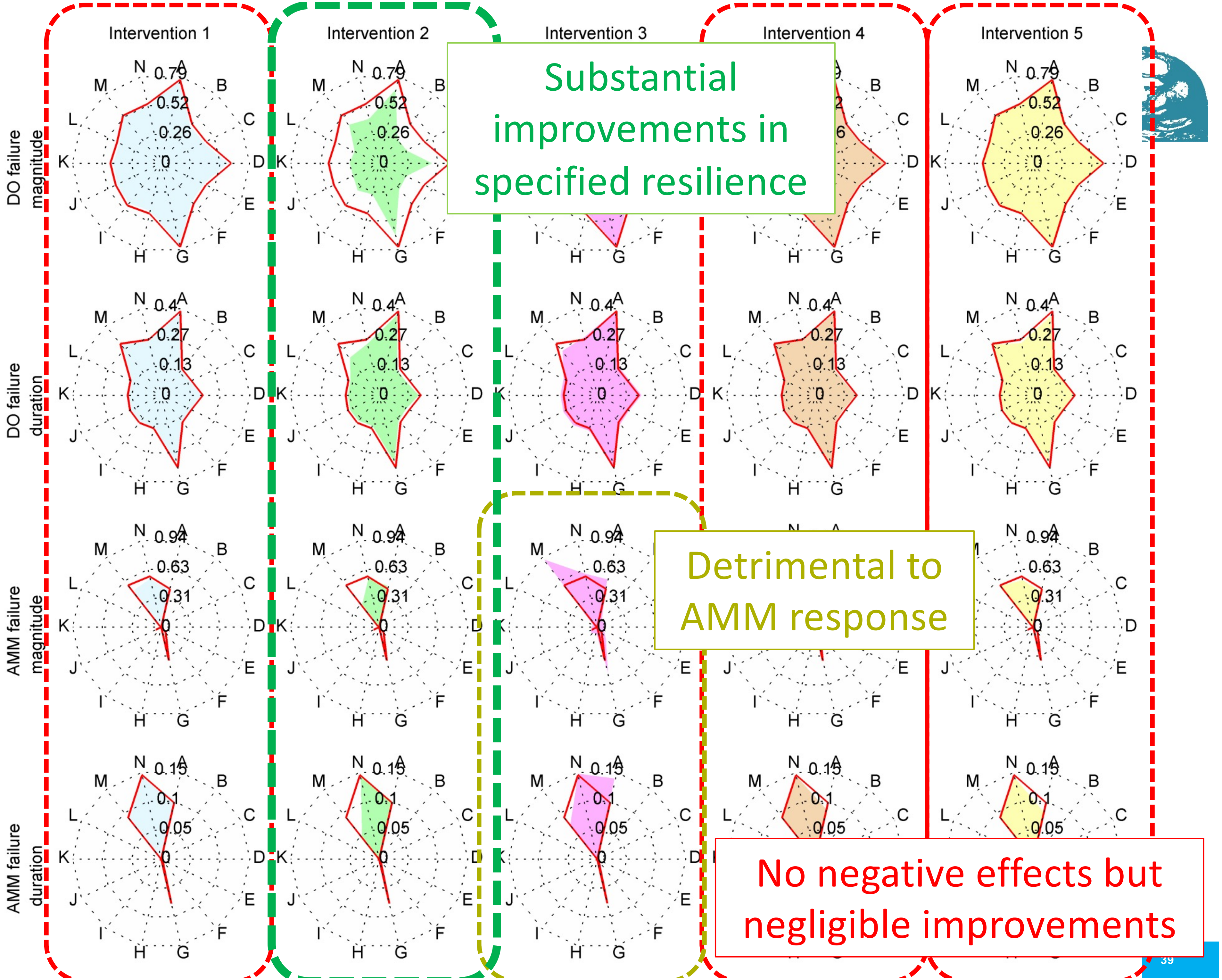
Increase in sewer influent flow

Failure of activated sludge aeration

STEP 3: Develop interventions

→ Address priority level of service measures and system failure modes identified

1. *Increase flow attenuation in catchments*
2. *Increase maximum outflow from sewer storage tank preceding WWTP*
3. *Increase capacity of sewer storage tank preceding WWTP*
4. *Increase activated sludge aeration tank volume*
5. *Increase capacity of WWTP storm tank*



Intervention 1
Intervention 2
Intervention 3
Intervention 4
Intervention 5
DO failure magnitude
DO failure duration
AMM failure magnitude
AMM failure duration
Substantial improvements in specified resilience
Detrimental to AMM response
No negative effects but negligible improvements

Concluding remarks

- A middle state based approach allows the potential effects on level of service resulting from any threat to be determined without knowledge of unknowns
- General resilience can be decomposed into multiple contributing components, each of which can be calculated individually
- General resilience assessment enables identification of priority level of service measures and failure modes
- Substantial improvement in specified resilience may be achieved with relative ease but achieving significant improvement in general resilience is challenging

Thanks to the whole S & S team: Prof David Butler, Prof Raziyeh Farmani & Dr Chris Sweetapple.

Sweetapple C., Fu G., Farmani R., Butler D. **General resilience: conceptual formulation and quantitative assessment for intervention development in the urban wastewater system.** *Water Research* (in review).

EPSRC Engineering and Physical Sciences Research Council

THE ROYAL SOCIETY

The Alan Turing Institute

AGENDA AND HOUSEKEEPING

Speaker 1
Timothy Holloway (University of Portsmouth, UK)

Speaker 2
Guangtao Fu (University of Exeter, UK)

Speaker 3
Seda Sucu (University of Portsmouth, UK)

Q&A Session moderator: *Maria Molinos-Senante (Universidad Católica de Chile)*

- This session is being recorded;
- Microphones and cameras have been disabled due to the large number of attendees;
- The normal chat function is disabled;
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).

MODELLING OPTIMAL PROCESS SELECTION FOR RESOURCE RECOVERY FROM URBAN WASTEWATER: NEREUS MULTI-CRITERIA DECISION SUPPORT TOOL

University of Portsmouth, 21.10.2021
Dr Seda Sucu, seda.sucu@port.ac.uk

AGENDA

- Description, Aims & Objectives of NEREUS Project
- Conceptual Framework of NEREUS DST
- Weighted Multi-Objective Non-Linear Programming Model
- Case Study
- NEREUS DST Algorithm
- Conclusion and Future Recommendation
- Questions and Answers

NEREUS PROJECT
New energy and resources from urban sanitation

European Regional Development Fund

The NEREUS project boosts the adoption of technologies that recover resources, water and energy from wastewater in urban areas.


Water reuse


Nutrient recovery


Energy recovery

Goals

- Performance efficiency test of demo technologies
- Provide strategy of involving DMs more in the selection of technologies
- Develop a DST provide economic, environmental, social and technical impact of various technologies
- A strategy to create acceptance of the community

NEREUS PROJECT PILOT PARTNERS

Water Reuse | Nutrient Recovery | Energy Recovery

Antwerpen Nieuw-Zuid, BE
water-link

Nieuwe Dokken Gent, BE
Ducoop

Saint-Omer WWTP, FR
CAPSO

Rotterdam/Delft, NL
Evides

Peel Common WWTP, UK
Southern Water

NEREUS PROJECT KNOWLEDGE PARTNERS

UNIVERSITY OF PORTSMOUTH

Prof Djamila Ouelhadj

Prof John Williams

Dr Brett Martinson

Dr Peter Cruddas

Dr Kevin Willis

Dr Ramazan Esmeli

HZ UNIVERSITY OF APPLIED SCIENCES

Dr Hans Cappon

MSc Maria van Schaik

NEREUS WEB-BASED DECISION SUPPORT TOOL

NEREUS
New energy and resources from urban sanitation

Circulair economy

Interreg
2 Seas Mers Zeeën

Home User Manual Knowledge Library User Input DST Output FAQ

Welcome to NEREUS Decision Support Tool

NEREUS DST aims to enables public and private decision-makers to evaluate the impacts of different recovery options and generate resource recovery trains with specific information on suitable technologies.

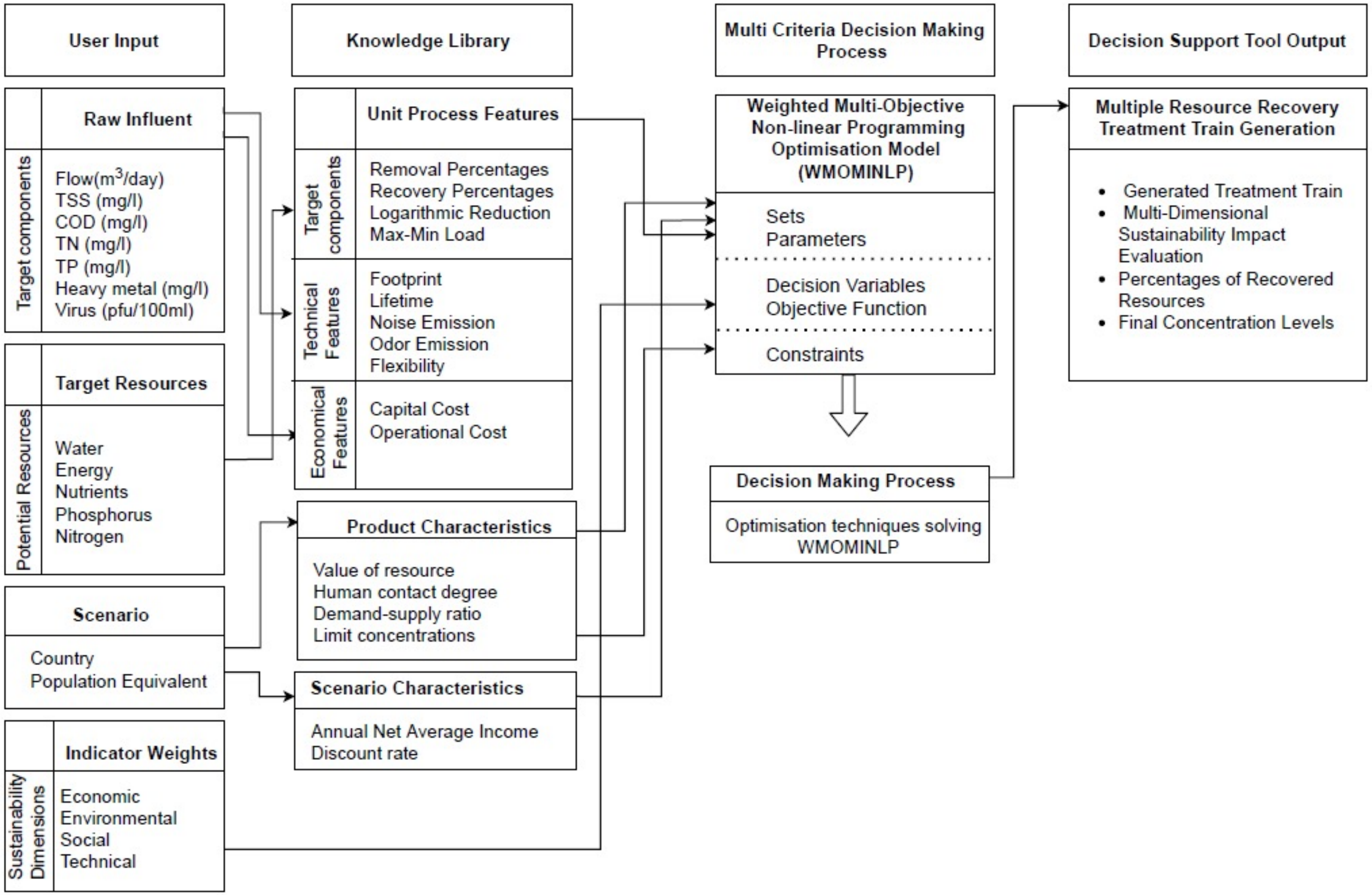
AIMS & MOTIVATIONS

Generating optimal treatment trains is challenging due to:

1. the vast number of available unit processes
2. the variability of wastewater influents in quantity and quality with time and location
3. the variability in the influence and selected unit process has on the downstream processes
4. multiple targeted resources
5. multiple conflicting objectives
6. geographical and social context based regulatory requirements

NEREUS WEB-BASED DECISION SUPPORT TOOL

CONCEPTUAL FRAMEWORK



NEREUS WEB-BASED DECISION SUPPORT TOOL

KEY PERFORMANCE INDICATORS

Economic

Equivalent Annual Cost

CAPEX & OPEX

Potential Income Generation

Willingness to pay

Environmental

Effluent Quality

Noise

Odo

Land

Sustainabi

Social

Risk of Infection

Risk of Toxic Compound

Acceptability

Affordability

Flexi

Relia

Journal of Environmental Management 282 (2021) 111916

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

ELSEVIER

Research article

Mathematically formulated key performance indicators for design and evaluation of treatment trains for resource recovery from urban wastewater

Maria O. van Schaik [a,*], Seda Sucu [b], Hans J. Cappon [a,c], Wei-Shan Chen [c], D. Brett Martinson [d], Djamila Ouelhadj [b], Huub H.M. Rijnaarts [c]

[a] HZ University of Applied Sciences, PO364 4380, AJ, Vlissingen, the Netherlands
[b] School of Maths and Physics, University of Portsmouth, Portsmouth, UK
[c] Environmental Technology, Wageningen University and Research, PO17 6700AA, Wageningen, the Netherlands
[d] School of Engineering and Surveying, University of Portsmouth, UK

ARTICLE INFO

Keywords:
Resource recovery
Urban wastewater key
Performance indicators treatment train evaluation
Unit process evaluation

ABSTRACT

While urban wastewater infrastructure is aging and no longer adequate, climate change and sustainability are urging the transition from pollution management to resource recovery. Lacking evidence-based quantitative evaluation of the potential benefits and consequences of resource recovery from wastewater hinders the negotiation amongst stakeholders and slows down the transition. This study proposes mathematical formulations for technical, environmental, economic, and social key performance indicators (KPIs) that can be used to quantify the benefits and the risks of resource recovery. The proposed formulations are derived from the literature and validated with stakeholders. Each KPI is mathematically formulated at treatment train level by considering: (1) the characteristics of individual unit processes (UPs) in the treatment train (TT), (2) the context in which the TT is installed, and (3) the resources to be recovered. The mathematical formulations of the KPIs proposed in this study enable a transparent, consistent and informative evaluation of existing treatment trains, as well as support the (computer aided) design of new ones. This could aid the transition from urban wastewater treatment to resource recovery from urban wastewater.

NEREUS WEB-BASED DECISION SUPPORT TOOL

MIXED INTEGER LINEAR PROGRAMMING MODEL

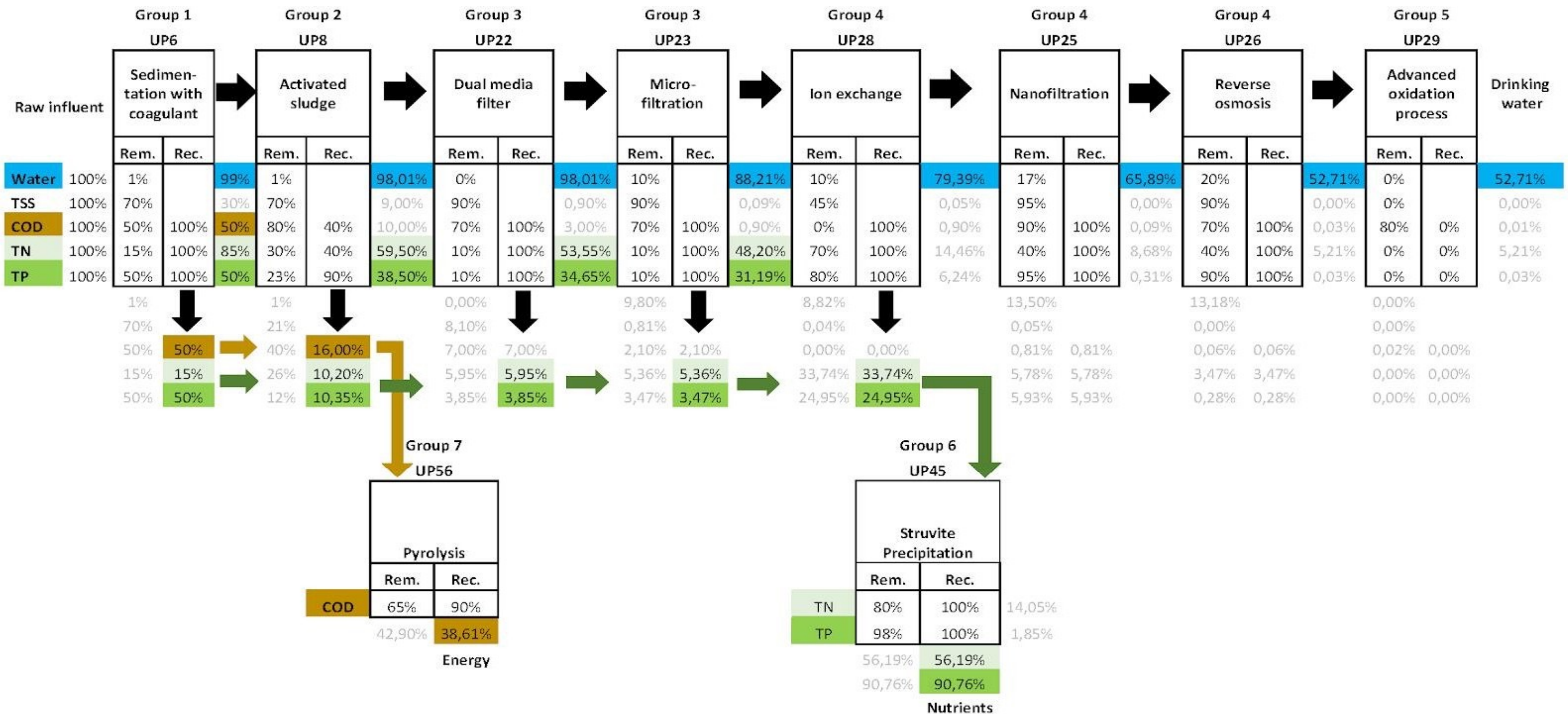
MODELLING COMPONENTS	
Sets	• Unit process groups • Tasks • Type of recovery products • Criteria
Parameters	• Unit process removal/ recovery percentages • Targeted products • Product characteristics • Sustainability objective targets
Decision variables	• Selection of unit process
Constraints	• Mass calculation of recovery products • Ensuring the unit process for recovery • Ensuring compatibility between unit processes • Compliance with regulations
Objective function	• Minimising the weighted sum of normalised distance from targeted objectives

CASE STUDY

- Weighted multi-objective model is implemented in GAMS (academic version) and BARON solver is used to solve the model
- Solution time is <=1 minute

Targeted resources	Weights
Energy (E); Nitrogen (N); Phosphorus (P); Drinking Water (D)	Equal weighting, %25 each

Flow (m3/day)	Population Equivalent (# of people)	Influent COD (mg/l)	Influent TSS (mg/l)	Influent TP (mg/l)	Influent TN (mg/l)	Influent Lead (mg/l)	Influent Vir (cfu/100ml)
100 000	400000	464	193	6.6	60	0.1	10000000



NEREUS WEB-BASED DECISION SUPPORT TOOL

CASE STUDY RESULTS

Scenarios	Flow (m3/day)	Population Equivalent (# of people)	Influent COD (mg/l)	Influent TSS (mg/l)	Influent TP (mg/l)	Influent TN (mg/l)	Influent Lead (mg/l)	Influent Vir (cfu/100ml)
Scenario 1	100 000	400000	464	193	6.6	60	0.1	10000000
Scenario 2	3 500	20000	500	300	11	44	0.1	10000000

Criteria	Economic		Environmental			Social		Technical	Weighted
KPIs	EAC	PIG	Noise	Odor	Land Requirement	Affordability	Acceptability	Flexibility	Multi-obj
Units	euro/year	euro/year	dB	-	m2	-	-	-	-
Scenario 1	€ 53,535,280	€ 27,114,910	24	3	218148	15	3	6	0.42
Scenario 2	€ 4,915,964	€ 881,218	24	4	4119	8	3	6	0.50

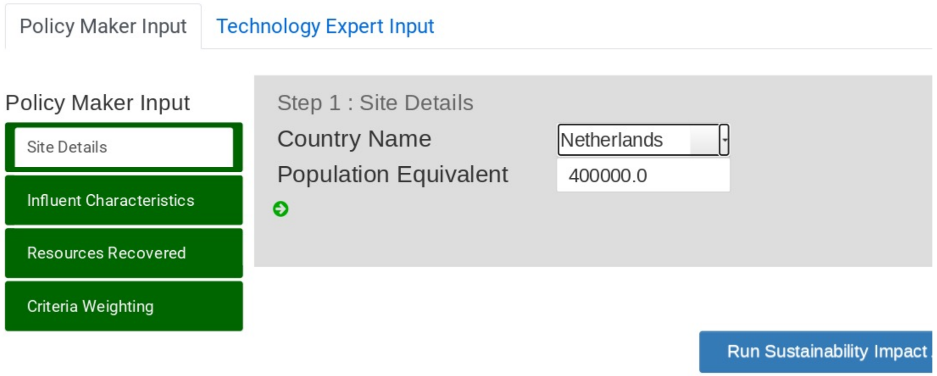
Final concentration	Unit	Scenario 1- Large	Scenario 2- Small	Drinking Water
COD	mg/L	0.05	0.05	0.1
TSS	mg/L	0.00	0.00	0.01
TN	mg/L	5.93	7.95	10
TP	mg/L	0.00	0.02	0.03

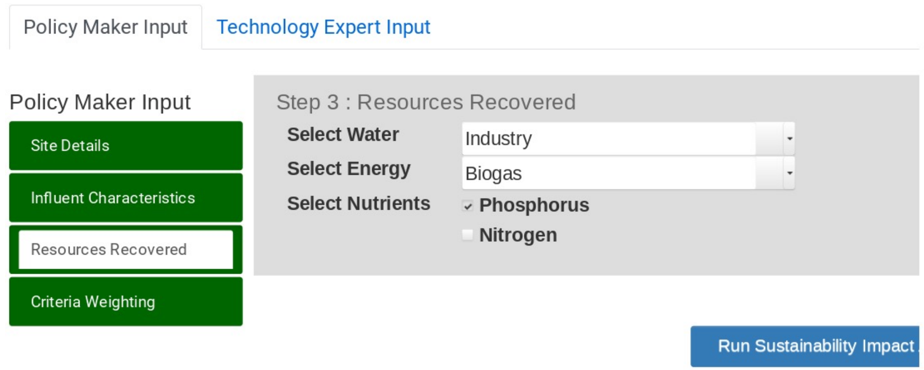
IMPLEMENTATION OF SEARCH ALGORITHM

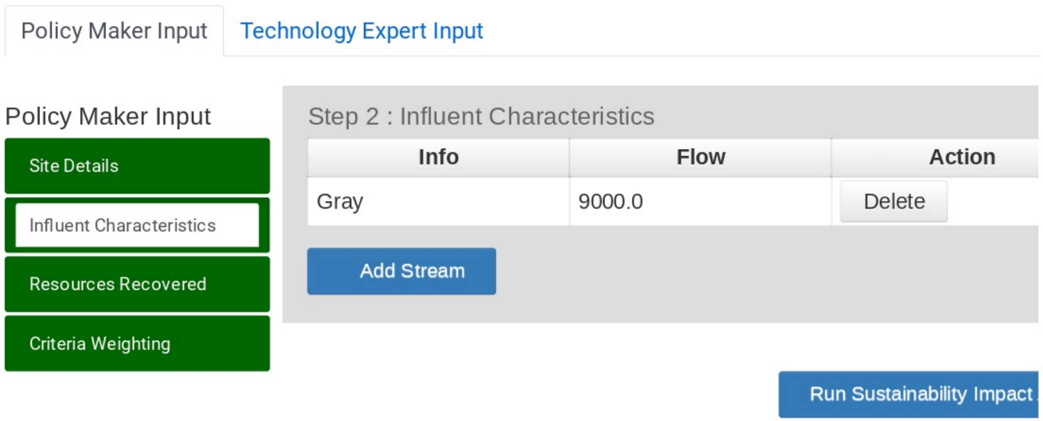
1. **Main Stream Generation:**
   - **Candidate Unit Processes** based on min-max concentration level of pre-selected compounds
   - **Unit Process Selection :** weighted-sum of multi-criteria
   - **Effluent (Product) Quality Control:** Final concentration <= Regulation limit based on country & product
2. **Side Stream Selection:** higher Mass Balances
   - **Unit Process Selection** based on higher resource recovery percentage
3. **Evaluation of each Criteria**
4. **Overall Weighted Criteria Calculation**

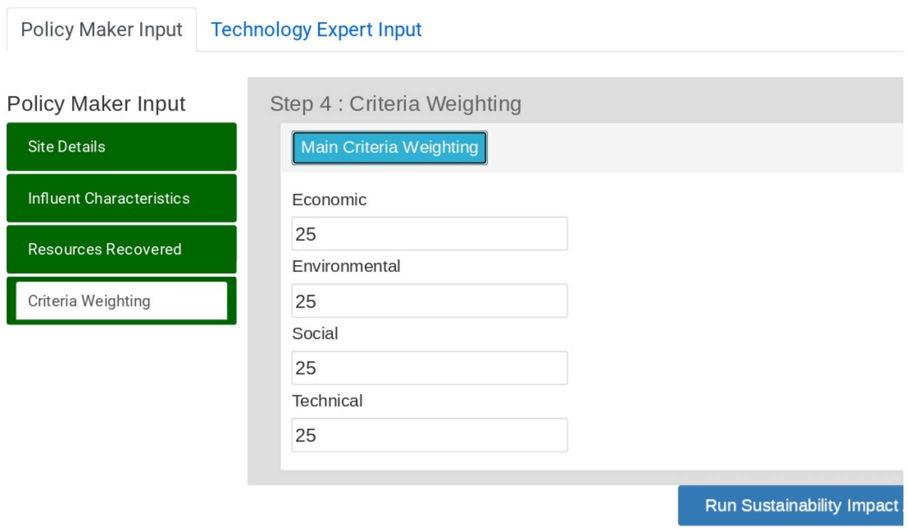
NEREUS WEB-BASED DECISION SUPPORT TOOL

USER INTERFACE



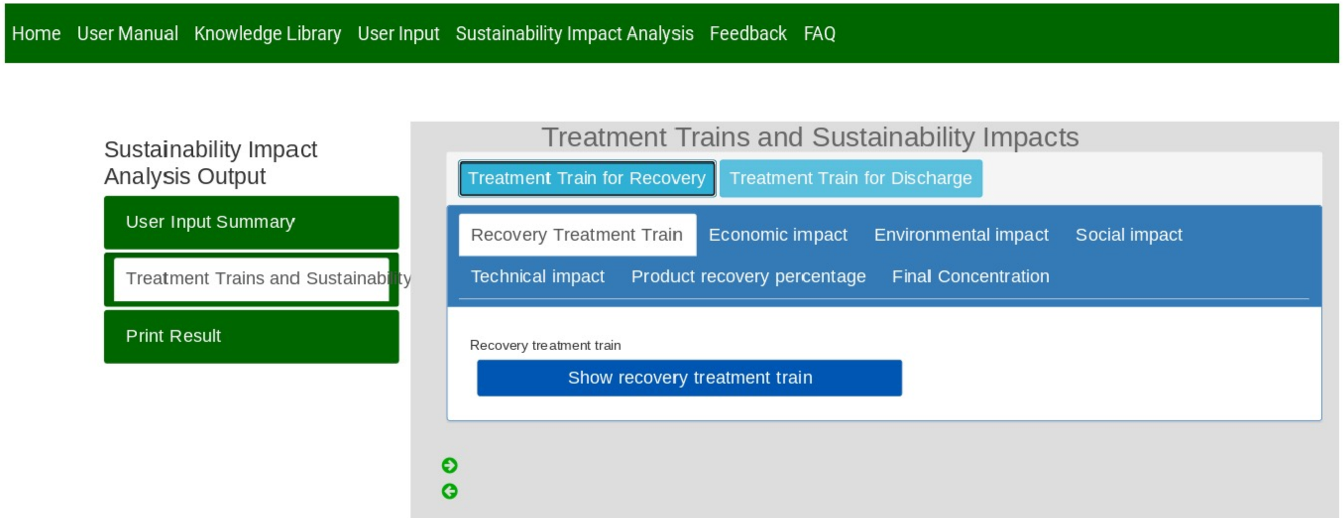






NEREUS WEB-BASED DECISION SUPPORT TOOL

USER INTERFACE



Resource recovery option

Discharge option

CONCLUSIONS & FUTURE WORK

- NEREUS web-based DST generate wastewater resource recovery trains via dynamic customized heuristic
- Economic, environmental, social and technical dimensions simultaneously considered and evaluated in the DST
- For future improvements:
  - Integration of LCA
  - Fine-tuning in search algorithm
  - Further validation of findings

THANK YOU

This project has received funding from the Interreg 2 Seas programme 2014-2020 co-funded by the European Regional Development Fund under subsidy contract No 2S03-011

Dr Seda Sucu, University of Portsmouth
seda.sucu@port.ac.uk

AGENDA AND HOUSEKEEPING

Speaker 1
Timothy Holloway (University of Portsmouth, UK)

Speaker 2
Guangtao Fu (University of Exeter, UK)

Speaker 3
Seda Sucu (University of Portsmouth, UK)

Q&A Session moderator: *Maria Molinos-Senante (Universidad Católica de Chile)*

- This session is being recorded;
- Microphones and cameras have been disabled due to the large number of attendees;
- The normal chat function is disabled;
- Please put any questions and comments you may have in the Q&A and we will do our best to answer them during the session (in writing or orally).

CLOSING REMARKS

Great thanks to all presenters for a wonderful show!

Look out for MIA's NEXT webinar on November 22, 2021:

"Anaerobic Digestion Modelling – Quo Vadis?" (working title)

If you have ideas for your own future webinar then contact MIA MC and we will help you make it happen!

Find out more at

http://iwa-mia.org/

https://iwa-connect.org