



9th Water Resource Recovery Modelling Seminar

Notre Dame, Indiana, USA | April 6 – 10, 2024



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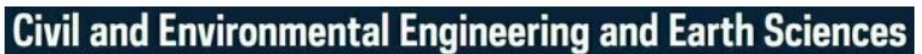
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WRRmod2024 Program

Saturday April 6, 2024			
Activity	Time	Details	Speakers
YWP Workshop	08:30 – 10:00	Presentations and Discussion	YWP workshop description and agenda at the end of the program
	10:00 – 10:30	Break	
	10:30 – 12:00	Presentations and Discussion	
	12:00 – 1:30	Lunch	
	1:30 – 3:00	Presentations and Discussion	
	3:00 – 3:30	Break	
	3:30 – 5:00	Presentations and Discussion	
YWP Social	5:00-7:00	YWP Social Event	
	7:00-8:00	Special Eclipse Event for All WRRmod attendees	

Sunday April 7, 2024			
Activity	Time	Details	Speakers
Parallel Half and Full-Day Workshops See list of workshop titles below	08:30 – 10:00	Presentations and Discussion	Workshop descriptions and agendas at the end of the program.
	10:00 – 10:30	Break	
	10:30 – 12:00	Presentations and Discussion	
	12:00 – 1:30	Lunch	
	1:30 – 3:00	Presentations and Discussion	
	3:00 – 3:30	Break	
	3:30 – 5:00	Presentations and Discussion	
Poster Session	5:00-7:00	Welcome Happy Hour & Poster Session	

Length	Workshop
Half day, morning	A. Modelling Decentralized Systems: A Framework for Maximizing the Benefits of Distributed Treatment Technologies
Half day, morning	B. Evaluating the Hybrid Modelling Competition: A Step Towards Developing Good Modelling Practice
Half day, afternoon	C. A Utility Perspective on Digital Twins as Operational Tools: Four Plants, Four Digital Twins
Half day, afternoon	D. Dissolution Revolution? To Refine Hydrolysis Models or Improve Existing Modelling
Full day	E. WRRF Influent Soft Sensors – Do All Paths Lead to Rome?
Full day	F. Utility-Focused Application of Models
Full day	G. Using Models to Advance Continuous Flow Granulation/Densified Activated Sludge
Full day	H. N2O Modelling

Monday April 8, 2024			
Activity and Moderators	Time	Details	Speakers
Opening Session	8:30-9:00	Welcome Remarks	Rob Nerenberg Leon Downing
	9:00-10:00	Keynote Address	Art Umble
	10:00-10:30	Break	
Session 1: MABR Modelling Assessment Moderators: Kelly Gordon Nerea Uri Carreño	10:30-12:00	<i>Modelling the Effect of Temperature on Nitrifying Membrane Aerated Biofilm Reactors</i>	E. Clements, Y. Nahum , B. Kim, P. Pérez-Calleja, R. Nerenberg
		<i>Modelling N₂O Emissions in Hybrid MABRs Is No 'Laughing' Matter</i>	N. Lakshminarasimman , O. Schraa, M. Zamanzadeh, W. Parker
	12:00-1:30	Lunch	
Session 2: Workshop Summaries	1:30-3:00	Workshop Summary Poster Session Partial Solar Eclipse Viewing	
	3:00-3:30	Break Partial Solar Eclipse Viewing	
Session 3: CFD and Compartmental Models Moderators: Stefan Weijers Amanda Lake	3:30-5:00	<i>Coupling Biokinetic Conversion Models with Computational Fluid Dynamics for Simulating Anaerobic Digesters</i>	P. Kumar , J. Yan, W. Rauch
		<i>Compartmental Model of the Anaerobic Tank at Yorkville STP for Modelling Bio-P Removal and the Impact of Mixing Behavior</i>	S. Duchi, G. Bellandi , N. Astrand , J. Gagnon, U. Rehman
Dinner	6:00-9:00	Dinner and Activity Off-Site	

Tuesday April 9, 2024			
Activity and Moderators	Time	Details	Speakers
Session 4a: Twins, Hybrids and Data Moderators: Magnus Arnell Kate Newhart	8:30-10:00	<i>wwtwin: An Open-Source Modular Python Package for Digital Twin Applications of WRRFs</i>	S. Daneshgar , S. Borzooei, R. Peeters, S. Weijers, I. Nopens, E. Torfs
		<i>Full-Scale Development and Piloting of a Hybrid Digital Twin for Wastewater Operations Optimization</i>	B. Johnson , C. Yang, J. Registe, K. Lesnik, A. Menniti, K. Villez, D. Pienta, H. Stewart, T. Johnson, A. McClymont, M. Oristain, T. Peterson
	10:00-10:30	Break	
Session 4b: Twins, Hybrids and Data Moderators: Elena Torfs Keaton Lesnik	10:30-12:00	<i>Comparing Methods for Estimating High-Frequency WWTP Influent Concentration Data from Downstream Measurements</i>	C. Wärrff , B. Carlsson, M. Arnell, R. Saagi, F. Micolucci, U. Jeppsson
		<i>Leveraging a Hybrid Machine Learning/Mechanistic Process Model to Forecast Effluent Quality and Optimize Treatment Performance</i>	B. Shoener, P. Dunlap, C. Schoepke, I. Avila , L. Downing
	12:00-1:30	Lunch	
Session 5: Low Energy Nitrogen Removal Moderators: Tanja Rauch-Williams Heather Stewart	1:30-3:00	<i>PDNA: Coupling Fundamentals Mechanisms and Principals of Mathematical Modelling</i>	P. Izadi, M. Andalib , P. Izadi, A. Umble
		<i>Advancing Low DO Process Modelling – Conventional and Novel Methods to Measure, Model, and Validate Nitrifier Kinetic Adaptation</i>	K. McCullough , L. McIntosh, T. Rauch-Williams, P. Ackman, A. Ekster, N. Beach, M. Young, T. Weiland, S. Klaus, C. Bott, D. Rosso, F. Shabani, P. Vanrolleghem
	3:00-3:30	Break	
Session 6: Modelling New Populations to Improve Nutrient Removal Prediction Moderators: George Wells Dwight Houweling	3:30-5:00	<i>Development and Validation of a Phototrophic-Mixotrophic Process Model (PM2) and a Process Simulator for Microalgae-Based Wastewater Treatment</i>	G.-Y. Kim , H. Molitor, X. Zhang, Y. Li, N. Avila, B. Shoener, S. Schramm, S. Snowling, I. Bradley, A. Pinto, J. Guest
		<i>Harmonious Symbiosis of PAO, GAO, and DGAO in a Carbon-Limited Wastewater Treatment Plant</i>	F. Sabba , M. Farmer, P. Dunlap, C. Qin, J. Barnard, G. Wells, L. Downing
Dinner	6:00-9:00	Gala Dinner	

Wednesday April 10, 2024			
Activity and Moderators	Time	Details	Speakers
Session 7: Physics Informing Biological Design Moderators: Diego Rosso Laura Debel Hansen	8:30-10:00	<i>Dynamic Calibration of a New Secondary Settler Model Using Cand. Microthrix and Thiothrix as Predictors of Settling velocity</i>	V. Bakos, Y. Qiu, M. Mora, D. Buguña, M. Nierychlo, P. Nielsen, B. Plósz
		<i>Impact of Oxygen Transfer Dynamics on the Performance of an Aerobic Granular Sludge Reactor</i>	L. Strubbe, E. van Dijk, P. Carrera, M. van Loosdrecht, E. Volcke
	10:00-10:30	Break	
Closing Session	10:30-10:45	WRRmod2024 Summary	Adrienne Menniti Tom Johnson
	10:45-11:45	Closing Address and Discussion	Tanja Rauch-Williams
	11:45-12:00	WRRmod2026 Outlook	Juan Antonio Baeza Paloma Grau
	12:00-1:30	Lunch, Depart	

Poster Presentations

Model-derived insights in a two-phase anaerobic dynamic membrane bioreactor system for high-rate co-digestion. Kuang Zhu, Renata Starostka, Steven Skerlos, Lutgarde Raskin.

Mechanistic/data-driven hybrid prediction approach for data-limited situations in Digital Twin WRRF applications. Mohammadjavad Mehrani, Ryan Sanford, Enrico Ulisse Remigi, Christopher Eugen Gaszynski

A conceptual and computational model for integrated aquaponics. I. M. DiGiulio, J. E. Maneval, C. M. Bye, and K. R. Gilmore

Unique Stratification of Biofilm Density in MABR Biofilms: An Experimental and Modelling Study. M. Li, P. Perez-Calleja, B. Kim, C. Picioleanu, R. Nerenberg

Reliability of data-driven soft sensors under non-linear process conditions. MY Schneider, E Torfs, JP Carbajal

Nutrient management and process operation optimization using data-driven modelling, case study Loudoun Water, Virginia. Katya Bilyk, Wendell Khunjar, Kendra Sveum, Javad Roostaei, Ankit Pathak

Developing data-driven tools on controlled full-scale systems: case study on acoustic sensor development for TS measurement. G. Kittleson, K.N. Ngo, S. Islam, T. Duong, A. Massoudieh, R. Riffat, B. Kerkez, and H. De Clippeleir

Towards Improved Control of Filamentous Bulking: A Fuzzy-Logic-Based Risk Assessment Model for Industrial WWTPs. S.Borzooei, S.Daneshgar, L.Deblicek, R. Cornelissen, E. Van Den Broeck, P. De Langhe, I. Nopens, E. Torfs

Integrated Modelling Approach for Planning and Design of 106 MGD Densified Activated Sludge Facility for Metro Water Recovery. Dan Freedman, Rudy Maltos, Alyssa Mayer, Ron Latimer, Wendell Khunjar, Will Martin, Joe Rohrbacher, Alonso Griborio, Oliver Schraa, Vrunda Patel, Dwight Houweling, Chris Machado

Physics-informed Model for Accelerating Hydraulic Modelling in Sewer Networks. Jiuling Li, Keshab Sharma, Zhiguo Yuan

Prediction of key components at full-scale wastewater facility using a comparable deep-learning/machine-learning approach for Digital Twin application. Mohammadjavad Mehrani, Ryan Sanford, Enrico Ulisse Remigi, Fabio Polesel, Christopher Eugen Gaszynski

PeePyPoo: An Open-Source Framework for Hybrid Modelling of Water Systems. F. Wenk, E. Morgenroth, A. Froemelt.

Poster Presentations

Serial hybrid modelling approaches in response to data scarcity and lack of process understanding – GAC filtration as a typical example. T. Kaiser, S. Lackner

Pond modelling from a client’s perspective. M. Morera, P. Perez-Calleja, B. Rimaud, D. Houweling, R. Nerenberg

Using Artificial Intelligence to Predict Influent Flow based on Weather Forecast. A. Harinaivo, H. Hauduc, J. Wang, P. Budai, I. Takacs

Modelling the microbial quality of premise plumbing systems supplied with reclaimed water. Clements, C. Picioeanu, R. Nerenberg

Operator Training Simulator for MBR and Wet Weather Flow Management. Mallika Ramanathan, San Mateo Operator TBD, J.B. Neethling, Jacob Barclay, S.D. Snowling

Advisory system based on data-driven models to provide practical operational suggestions for WRRFs. M. Sadeghassadi, I. Miletic, L. Alejo, O. Schraa

Application of a new combined hydraulic and biological plant-wide model for trickling filters in a real WWTP. K. Olaciregui-Arizmendi, S. Jaray-Valdehiero, T. Fernández-Arévalo, A. López, J. Gómez, P. Grau, B. Elduayen-Echave and E. Ayesa

Data-driven prediction of N₂O in the activated sludge process: a linearized benchmark for model-based control. L.D. Hansen, J.-P. Calliess, S. Roberts, P.A. Stentoft, D. O. Arroyo, P. Durdevic

Designing a full-scale ozonation plant and its Digital Twin for maximum micropollutants removal and minimal bromate formation using Amozone kinetic model integrated with Computational Fluid Dynamics. R. Muoio, G. Bellandi, R. Schemen, P. van Horne, T.P.M. Spit, C.Y. de Jong, R. de Lepper, E. Buunk, R.J. van der Vleugel, U. Rehman, Wim Audenaert

An agile benchmarking framework for the evaluation of emerging wastewater treatment and resource recovery technologies. X. Zhang, S. Rai, B. D. Shoener, P. A. Vanrolleghem, R. D. Cusick, Y. Li, J. S. Guest

Challenges of Simulating THP for a “Real” World Full-Scale Application. Are our commercial simulators teaching the right message? Adrian Romero, Tom Johnson, Blake Anderson, Julian Sandino

Results of a Survey on Water Resource Recovery Modelling Practice. P. Dunlap*, D. Benisch, K. Solon, A. Filali, M. Garrido, T. Tokutomi

From Model to Decision: Pathway to Enhancing HRAS Clarifier Performance at Western Branch Water Resource Recovery Facility. I. Avila, C. Andres, A.J. Sorinolu, P. Dunlap, M. Ebrahimi, C. deBarbadillo

Evaluation of existing EBPR model matrixes- Sensitivity Analysis and determination of most influential parameters. P. Izadi, Y. Fang, M, Andalib

Young Water Professionals Workshop

YWP perspective on best practices for modelling for operations

Co-chairs: Lee Pinkerton and Christoffer Wärrf

Organizing group: Nerea Uri Carreño (advisor), Cheng Yang, Jennifer Loconsole, Kester McCullough, Gamze Kirim, Saba Daneshgar

Discussion leaders: Cheng Yang, Nerea Uri Carreño, Kester McCullough, Saba Daneshgar, Ksenija Golovko, Hanna Molin

Relevance and Goals

The purpose of the young water professional (YWP) workshop is:

- Give opportunity to YWPs network.
- Allow focussed discussion among YWPs.
- Prepare the YWPs for the content in the rest of the conference.
- Give an opportunity for YWPs to play an active role in a session.

The goal for the workshop is to identify, establish and share best practices for technical/non-technical challenges and solutions related to modelling for operations from the viewpoint of YWPs. The expected outcome from the workshop is a summarizing document of best practices based on the discussions held during the workshop. The questions that will be addressed at the workshop include:

- Data validation and reconciliation for offline and automated model settings.
- Deciding level of model complexity for the cases of secondary clarifier and hydrodynamics modelling.
- Validation of mechanistic and data driven models.
- Communication between disciplines and on-boarding of operators for model use.

Young Water Professionals Workshop Agenda

Time	Session
8.30 am – 10 am	Session 1 – Data management and validation
	Subtopic 1.1 – Data validation/reconciliation for N ₂ O measurements Speaker: Nerea Uri Carreño
	Subtopic 1.2 – Automated data reconciliation for digital twin applications Speaker: Saba Daneshgar
10 am – 10.30 am	Coffee break
10.30 am – 12 am	Session 2 – Complexity vs quality
	Subtopic 2.1 – Modelling secondary clarifiers. Speaker: Imre Takacs
	Subtopic 2.2 – Modelling hydrodynamics Speaker: TBA
12 pm – 1.30 pm	Lunch
1.30 pm – 3 pm	Session 3 – Model validation
	Subtopic 3.1 – Novel mechanistic model validation Speaker: Kester McCullough
	Subtopic 3.2 – Data driven model validation. Speaker: Laura Debel Hansen
3 pm – 3.30 pm	Coffee break
3.30 pm – 5 pm	Session 4 – Communication
	Subtopic 4.1 - Communicating between disciplines. Speaker: Keaton Lesnik
	Subtopic 4.2 – Gaining operator trust for operational use of models. Speaker: Adrienne Menniti

Workshop A: Modelling Decentralized Systems: A framework for maximizing the benefits of distributed treatment technologies (Half Day, Morning)

Chairs: Renata Starostka, Joe Lybik

Key Objectives:

- Identify the similarities and differences in assumptions, tools, and parameters utilized in modelling centralized treatment versus decentralized treatment.
- Highlight gaps that need to be overcome to enable implementation and operation of decentralized systems.
- Develop a framework for building comprehensive, federated models with gap and uncertainty analysis about essential parameters will be discussed.

Workshop Time	Activity
8:30 – 8:40	Introduction, outline, goals of workshop (<i>Renata Starostka and Joe Lybik</i>)
8:40 – 9:10	<p>Session 1: Moving from modelling centralized systems towards decentralized/distributed systems: What overlaps and gaps exist?</p> <p>First 3 research presentations (10 min each):</p> <ul style="list-style-type: none"> • <i>Peter Vanrolleghem</i> – Rethinking assumptions in the shift from centralized to decentralized treatment and recovery • <i>Manel Garrido-Baserba</i> – Modelling city block-scale decentralized systems using advanced digital twins • <i>George Wells</i> – Resource recovery technology analysis: Considerations and framework for comparison
9:10 - 9:30	Panel Discussion, moderated by <i>Lina Belia</i>
9:30 - 10:00	<p>Session 2: Leveraging modelling for implementation: How can we go from technology to product?</p> <p>Second 4 research presentations (10 min each):</p> <ul style="list-style-type: none"> • <i>Jeremy Guest or Xinyi Zhang</i> – QSDsan and other tools for design, analysis, and comparison of distributed sanitation systems • <i>Sara Schwetschenau</i> – Risks and failure analysis for distributed systems • <i>Daniel Yeh</i> – Automation and sensors for product development and implementation
10:00 – 10:30	Morning Coffee Break
10:30 - 10:50	Panel Discussion, moderated by <i>Lina Belia</i>
10:50 - 11:50	<p>Breakout Groups:</p> <ul style="list-style-type: none"> • Group #1: Federated Model Development/Decision Making • Group #2: Identifying Gaps and Uncertainties for Management/Implementation of Distributed Systems/Education/Community Engagement
11:50 - 12:00	Breakout Group Reporting (5 min each)

Workshop B: Evaluating the Hybrid Modelling Competition: A Step Towards Developing Good Modelling Practice (Half Day, Morning)

Chairs: MY Schneider, JJ Zhu

Key Objectives:

In this workshop, we aim to evaluate with participants, organizers, utilities (potential data providers), and other interested stakeholders the lessons learnt for establishing good modelling practices. This workshop represents the inception of designing best practices for hybrid modelling. Specific questions that will be tackled:

- How was the modelling framework (mechanistic, data-driven, hybrid) chosen?
- How was complexity of different modelling components determined?
- How was calibration and training achieved?
- When was the model deemed satisfactory?
- How were model explanation and causality analysis involved?
- Which were the main challenges encountered?

Workshop Time	Activity	Speakers (not all confirmed)
8:30– 8:45	Introduction: Overview of the challenge and key statistics, announcement of the winners	MY Schneider
8:45-9:15	Inputs on good modelling practice: IWA good modelling practice working group, good modelling practice in mechanistic and data-driven modelling paradigms	Mechanistic: K Solon, Data-driven: JJ Zhu
9:15– 9:45	Participants' experiences based on interviews with a focus on what guidelines for good modelling practice are missing	Moderator ARD Tafti L Verhaeghe and JD Therrien, F Wenk
9:45– 10:00	Brainstorming session part I: which topics are relevant for good modelling practice in hybrid modelling (e.g. model selection, calibration or uncertainty).	Moderator: S Daneshgar
10:00 – 10:30	Coffee break	
10:30 – 11:00	Brainstorming session part II: GMPs for mechanistic and data-driven models exist, can the two just be combined for hybrid modelling (e.g. sample size).	Moderator S Daneshgar
11:00 – 11:30	Group discussion on identified topics during the brainstorming sessions	Moderator: E Torfs All workshop participants
11:30 – 12:00	Panel discussion and roadmap to the future	Moderator: A Frömelt Panellists: A AlSayed, F Casagli, MY Schneider, K Solon, C Yang

Workshop C: A utility perspective on digital twins as operational tools: Four plants, four digital twins (Half Day, Afternoon)

Chairs: Annina Brupbacher, Adrienne Menniti

Key Questions:

- How can digital twin technology become a beneficial operational tool for resource recovery utilities?
- And what can modelers do to help with that?

Time	Activity	Speaker
1:30-1:35	Introduction	Nina Gubser, City of Zurich, Switzerland
Case study introduction: Goals of the project, intended end users, requirements, and costs		
1:35-1:45	City of Zurich	Annina Brupbacher, City of Zurich, Switzerland
1:45-1:55	Hampton Roads Sanitation District	Charles Bott, Hampton Roads Sanitation District, USA Peter Vanrolleghem, Université Laval
1:55-2:05	Clean Water Services	Adrienne Menniti, Clean Water Services, USA
2:05-2:15	Waterschap De Dommel	Stefan Weijers, Waterschap De Dommel, Netherlands
2:15-2:30	Group discussion	Annina Brupbacher, City of Zurich, Switzerland
Structure and performance: Overview of modelling approach, architecture, and data integrations; review of DT performance and use of the DT in the utility		
2:30-2:45	City of Zurich	Annina Brupbacher, City of Zurich, Switzerland
2:45-3:00	Hampton Roads Sanitation District	Charles Bott, Hampton Roads Sanitation District, USA Peter Vanrolleghem, Université Laval
3:00-3:30	Afternoon break	
3:30-3:45	Clean Water Services	Adrienne Menniti, Clean Water Services, USA
3:45-4:00	Waterschap De Dommel	Stefan Weijers, Waterschap De Dommel, Netherlands
4:00-4:15	Group discussion	Bruce Johnson, Jacobs, USA
Lessons Learned and Next Steps		
4:15-4:35	Lessons learned panel discussion: If we could start again, what would be done differently? Can these lessons be applied to other projects?	Elena Torfs, Université Laval, Canada
4:35-4:55	Next steps group discussion: What are the most pressing open questions to be addressed? What can we, as modelling leaders, do to facilitate successful adoption of DT at utilities?	Nina Gubser, City of Zurich, Switzerland
4:55-5:00	Concluding remarks	Nina Gubser, City of Zurich, Switzerland

Workshop D: Dissolution Revolution? To Refine Hydrolysis Models or Improve Existing Modelling Practice (Half Day, Afternoon)

Chairs: Patrick Dunlap, Colin Fitzgerald, Mark Miller

Key Objectives:

- Is it best to try and reduce uncertainty by incorporating additional model structures, or are better best practices for managing uncertainty needed?

Lunch Break		12:00-1:30
New Model Structures to Improve Prediction		1:30-3:00
Biological Background of Hydrolysis	G. Wells	15 minutes
Importance of hydrolysis models to BNR simulation	P. Dunlap	15 minutes
Balancing Hydrolysis and Internally Stored Carbon	D. Wankmuller	15 minutes
Differentiating Primary / Secondary Particulate Substrate	I. Takacs	15 minutes
Product Inhibition of Hydrolysis Reaction	P. Dold	15 minutes
Start of Breakout Sessions		
<ul style="list-style-type: none"> • Group 1: We need new model structures! • Group 2: We need better best practices! • Group 3: We need more research! • Group n: (open to other thesis statements) 	Audience	15 minutes
Afternoon Break		3:00-3:30
Moving Forward		3:30-5:00
Breakouts Continue / Wrap Up	Audience	20 minutes
<i>Presentations by Breakout Groups / Discussion</i>	<i>Audience</i>	<i>40 minutes</i>
Synthesis and Next Steps	Organizers	15 minutes

Workshop E: WRRF Influent Soft Sensors – Do all paths lead to Rome? (Full Day)

Chairs: Leiv Rieger, John Copp

Key Objectives:

- Define the different approaches to soft sensor design.
- Identify approaches for validation and data needs identification.
- Identify future needs to advance soft sensor development and application.

Time	Activity	Presenter/Moderator
8:30-8:35	Welcome and Introduction	Leiv Rieger
8:35-8:40	Intro Presentation: The value of WRRF Influent Soft Sensors	Leiv Rieger
8:40-9:40	Session 1: Influent Soft Sensor Designs – Case Studies a) Influent Generator – Derive full model influent from flow and selected concentration measurements b) Semi-Mechanistic Sewer Model – Tell me where you’ve been and I’ll calculate a plant influent c) Hybrid Approach – Colliding Worlds	Xavier Flores Alsina John Copp Bruce Johnson
9:40-10:00	Summary by moderator	Leiv Rieger
10:00-10:30	Coffee Break	
10:30-11:50	Session 2: Interactive Round Table Discussion a) Mechanistic, Empirical, Hybrid, Pure ML – Tell me what we don’t know b) Tools – What influent tools am I using? c) Validation – How do I make sure my influent does the right thing? d) Future – Where am I going?	Facilitators John Copp Leiv Rieger Bruce Johnson Saba Daneshgar
11:50-12:00	Moderated Plenum Discussion	Henry Croll
12-1:30	Lunch	
1:30-3:00	Session 3: Interactive Round Table Exercises	Facilitators John Copp Leiv Rieger Henry Croll
3:00-3:30	Coffee Break	
3:30-3:55	Moderated Plenum Discussion	John Copp
3:55-4:00	Workshop Wrap-up	Leiv Rieger & John Copp

Workshop F: Utility Focused Application of Models (Full Day)

Chairs: Leila Barker, Spencer Snowling, Oscar Samuelsson, Erik Lindblom

Key Objectives:

- Define key aspects for utility-based model development.
- Identify good practice for model use and maintenance for utilities.
- Review the key model use for utilities.

Time	Activity
08:30 – 08:45	Welcome, introductions, logistics (Leila Barker and Spencer Snowling)
08:45 – 10:00	<p>Session 1: Model Development Considerations: Case Studies and Lessons Learned</p> <ul style="list-style-type: none"> • Anne Conklin: Model development case studies and takeaways • George Sprouse: Process model development and use • Leila Barker: Internal utility coordination <p>Planning Ahead for Future Modelling</p> <ul style="list-style-type: none"> • Group activity: preparing utilities for success in future modelling efforts
10:00 – 10:30	Coffee break
10:30 – 12:00	<p>Session 2. Model Use and Maintenance</p> <ul style="list-style-type: none"> • Good modelling practice • Oscar Samuelsson: Futureproof model documentation – MetaCO (IWA TG) • Nina Gubser: Keeping models up to date; status quo and ideas • Activity: ranking key model metadata
12:00 – 13:30	Lunch
13:30 – 15:00	<p>Session 3. Problems for Utilities to Solve with Modelling</p> <ul style="list-style-type: none"> • Breakout discussion: Technical and implementation challenges faced by utilities • Panel discussion: Which problems can be addressed; approaches (Tom Johnson, others) <p>Uncertainty During Design</p> <ul style="list-style-type: none"> • Spencer Snowling: Analysis of uncertainties during design
15:00 – 15:30	Midafternoon break
15:00 – 17:00	<p>Session 4. (How) Can Design Safety Factors Be Replaced by Process Model Scenarios?</p> <ul style="list-style-type: none"> • Erik Lindblom: A methodology for process model-based design • Group work about design scenarios vs. safety factors • Discussion with expert panel (Glen Daigger, others)

Workshop G: Using Models to Advance Continuous Flow Granulation/Densified Activated Sludge (Full Day)

Chairs: Leon Downing, Jose Jimenez

Key Objectives:

- How do we use models to better understand the potential for granulation/densification in continuous flow systems?
- Do we need to model granules, or just model the indicators of granules?
- What needs to be changed for clarifier models for granules/densified activated sludge?

Time	Activity	Speaker
Modeling Conditions for Granule Formation		
8:30-9:00	What drives the formation of granules in activated sludge?	Belinda Sturm
9:00 to 9:30	How are we currently modelling granular sludge reactors?	Eberhard Morgenroth
9:30 to 10:00	Advancing the modelling of mobile biofilms to simulate continuous flow granules.	Josh Boltz
10:00 to 10:30	Break	
Exploring New (and old) Approaches for Granule Formation		
10:30 to 10:50	Using modelling tools to identify granule growth pressures and account for selective wasting. Tom Johnson	Tom Johnson
10:50 to 11:10	Modelling Granules or modelling granulation? The case for 0-d. Dwight Houweling	Dwight Houweling
11:10 to 11:30	How many OHOs is too many OHOs? Leon Downing	Leon Downing
11:30 to 12:00	Debate: is the complexity of mobile biofilms required, or is population manipulation and growth pressure simulation sufficient?	Jose Jimenez
12:00 to 13:30	Lunch	
Exploring New (and old) Approaches for Granule Formation		
13:30 to 13:50	Flocs, Granules, Clarifier Performance and Membrane Filterability too!	Sylvain Donnaz
13:50 to 14:10	Hybrid modelling to predict granulation and effluent TSS performance?	Isaac Avila
14:10 to 14:30	Extending EPS modelling and flocculation in high rate AS systems to granulation	Jose Jimenez
14:30 to 15:00	The role of CFD in continuous flow granulation systems.	Ed Wicklein
15:00 to 15:30 Break		
What is needed from our models to advance continuous flow granulation?		
15:30 to 15:45	Why is this important, and what have we learned today?	Leon Downing, Jose Jimenez, Belinda Sturm
15:45 to 16:30	Discussion 1: What tools do we need to better predict SVI? Discussion 2: Do we need to adjust our clarifier modeling approaches?	
16:30 to 17:00	Consensus paper outline	

Workshop H: N₂O Modelling Workshop (aka "N(2)O panic") (Full Day)

Chairs: Giacomo Bellandi, Nerea Uri Carreño, and Andreas Frömelt.

Key Objectives:

- Discuss the available measurement tools for N₂O and their analytical resolution, uncertainty, and field applicability.
- Understand the challenges faced by utilities in measuring and mitigating N₂O emissions.
- Explore the state of the art in research, including known N₂O production pathways and the impact of different technologies.
- Present an overview of existing N₂O modelling frameworks, their integration with measurements, and their applications and status.
- Assess data quality, uncertainty, and mitigation experiences related to N₂O modelling.
- Identify the needs of utilities and match them with different types of N₂O models

Time	Description	Presenter/ Moderator
8.30	Opening and Welcome:	Giacomo Bellandi (AM-Team, BE)
8.45 - 9.15	General Introduction on N₂O	
	Overview of N ₂ O and its global impacts on the water sector Reporting guidelines and potential mitigation strategies.	Amanda Lake (Jacobs, UK)
	Legislative models in different countries/regions	Nerea Uri Carreno (VCS) Laura Debel Hansen (Kruger, DK)
9.15 - 10.00	Measurement approaches for N₂O	
	Presentation 1: Measurement tools, their analytical resolution, uncertainty, and field applicability.	Nerea Uri Carreno (VCS) Giacomo Bellandi (AM-Team, BE)
	Challenges of Utilities in N ₂ O Measurement and Mitigation	Alexandra Deeke (De Dommel, NL) Tom Weijtmans (Aa en Maas, NL)
	Current use of models for N ₂ O by Utilities	Tony Flaming (WDO Delta, NL) Eteke Wypkema (BrabantseDelta, NL)
10.00 - 10.30	Coffee	

Time	Description	Presenter/ Moderator
10.30 - 11.15	State of the Art in N₂O Research	
	Overview of N ₂ O production pathways	Carlos Domingo-Felez (University of Glasgow, UK)
	Assessing the impact of different technologies on N ₂ O emissions	NarasimmanLakshminarasimman Meanakshi Se (Waterloo University, CA)
	Exploring the latest research on N ₂ O measurement, analytical resolution, and uncertainty	CarlosDomingo-Felez (University of Glasgow, UK)
11:15 - 12.00	Group discussion	Nerea Uri Carreno (VandCenter,DK)
12.00 - 13.30	Lunch	
13.30 - 13.45	Wrap-up from the morning	Nerea Uri Carreno (VCS,DK)
13.45 - 15.00	Available Models for N₂O	
	Overview of existing N ₂ O modelling frameworks	Andreas Freomelt (EAWAG, CH) Laurence Strubbe(EAWAG,CH) Arne Freyschmidt (Hannover University, DE) Maike Beier (Hannover University, DE) Oliver Schraa (InCtr, US) Gurkan Sin (DTU, DK)
15.00 - 15:30	Coffee	
15.30 - 16.30	Model Applications	Laura Debel Hansen (Kruger, DK) Jose Porro (Cobalt Water, US) Oliver Schraa (InCtr,US) Giacomo Bellandi (AM-Team, BE)
16.30- 17.00	Discussion and wrap-up	Giacomo Bellandi (AM-Team, BE)