FUTURE SUPPLY ACTIONS PROGRAM
WEBINAR SERIES

ARTIFICIAL INTELLIGENCE STUDY
March 23, 2023

One Water
THE METROPOLITAN WATER DISTRICT of SOUTHERN CALIFORNIA

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

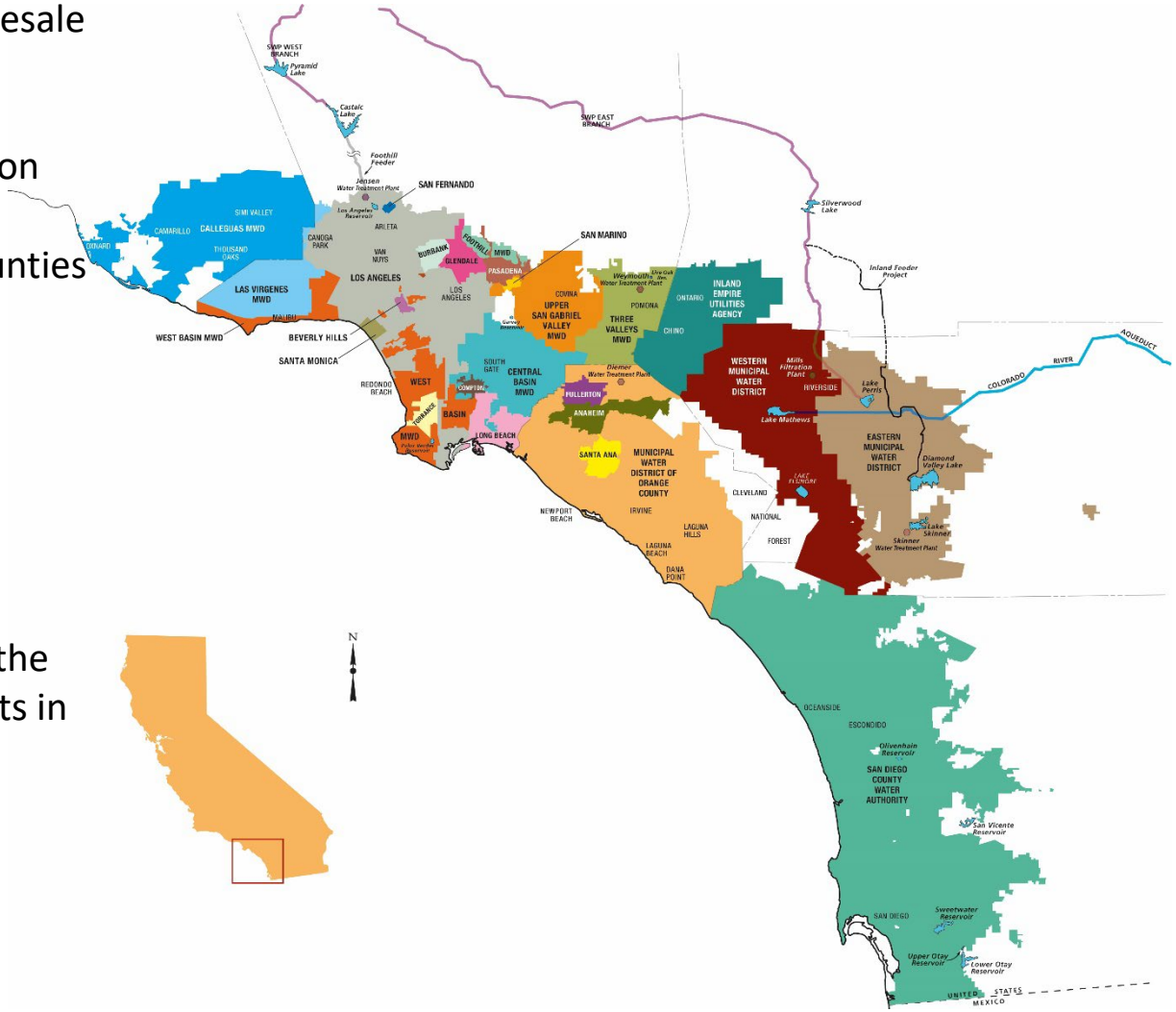
LAS VIRGENES MUNICIPAL WATER DISTRICT EST. 1958

carollo®

Agenda

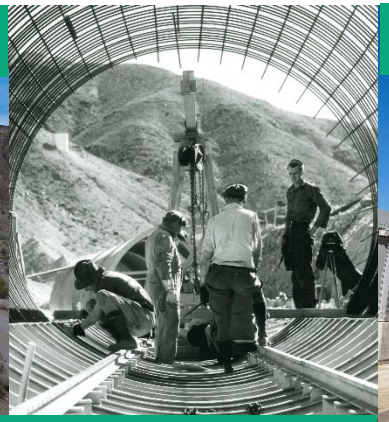
The Metropolitan Water District of Southern California

- Nation's largest wholesale water provider
- Service area: 19 million people/5,200 square miles/parts of six counties
- 26 member agencies
- Supports $1 trillion regional economy
- Imports water from Northern Sierra and the Colorado River, invests in local projects



Metropolitan's Role for Southern CA

REGIONAL PROVIDER

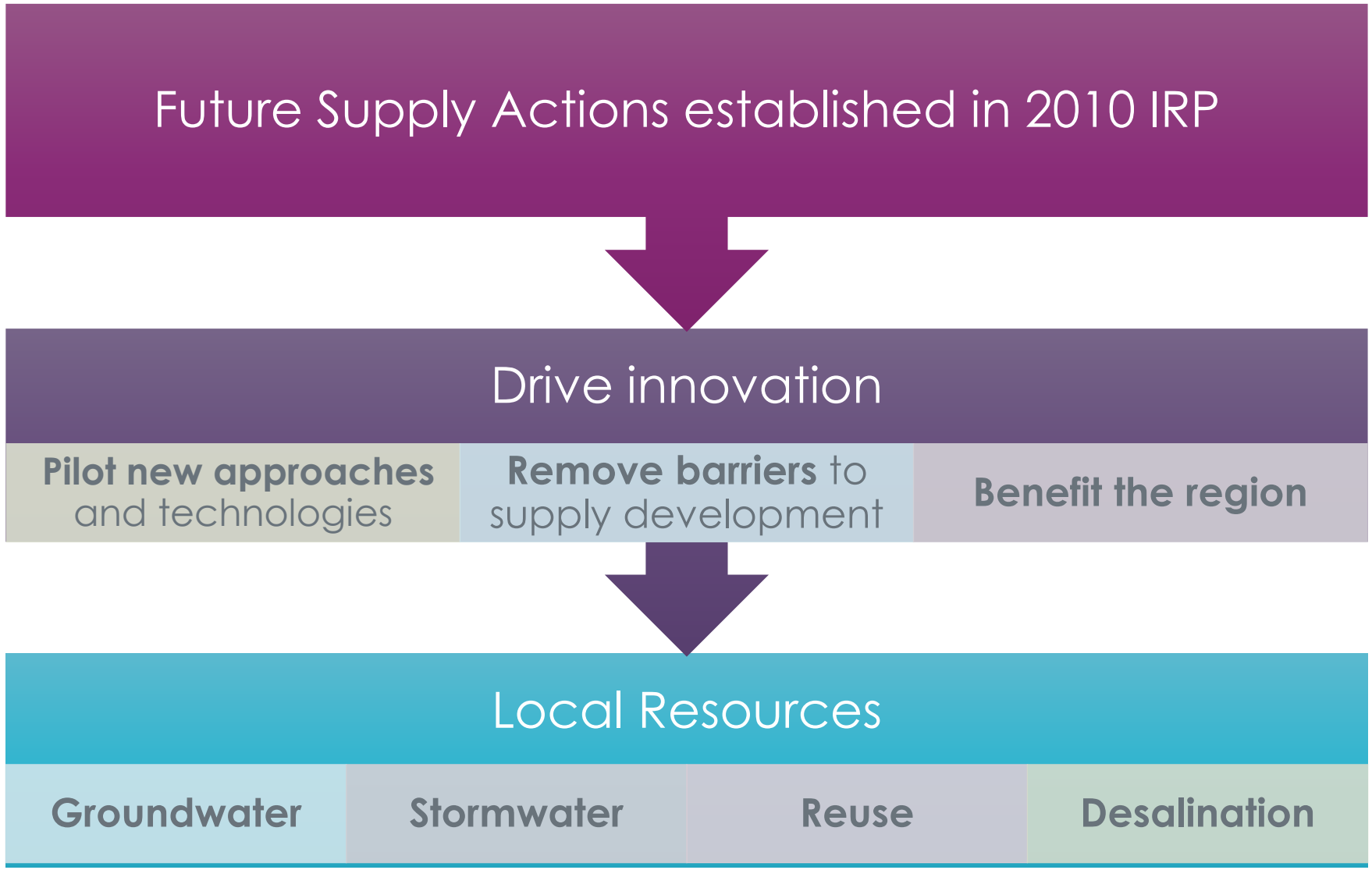


INNOVATION

VISION

SAFE & RELIABLE

Future Supply Actions Funding Program



Current Program

Member Agency

- 14 studies
- $3.1 million

Water Research Foundation

- 6 potable reuse studies
- 1 agricultural reuse study
- $975k

Speaker Spotlight

John Zhao

Las Virgenes Municipal Water District

Andrew Salveson

Carollo

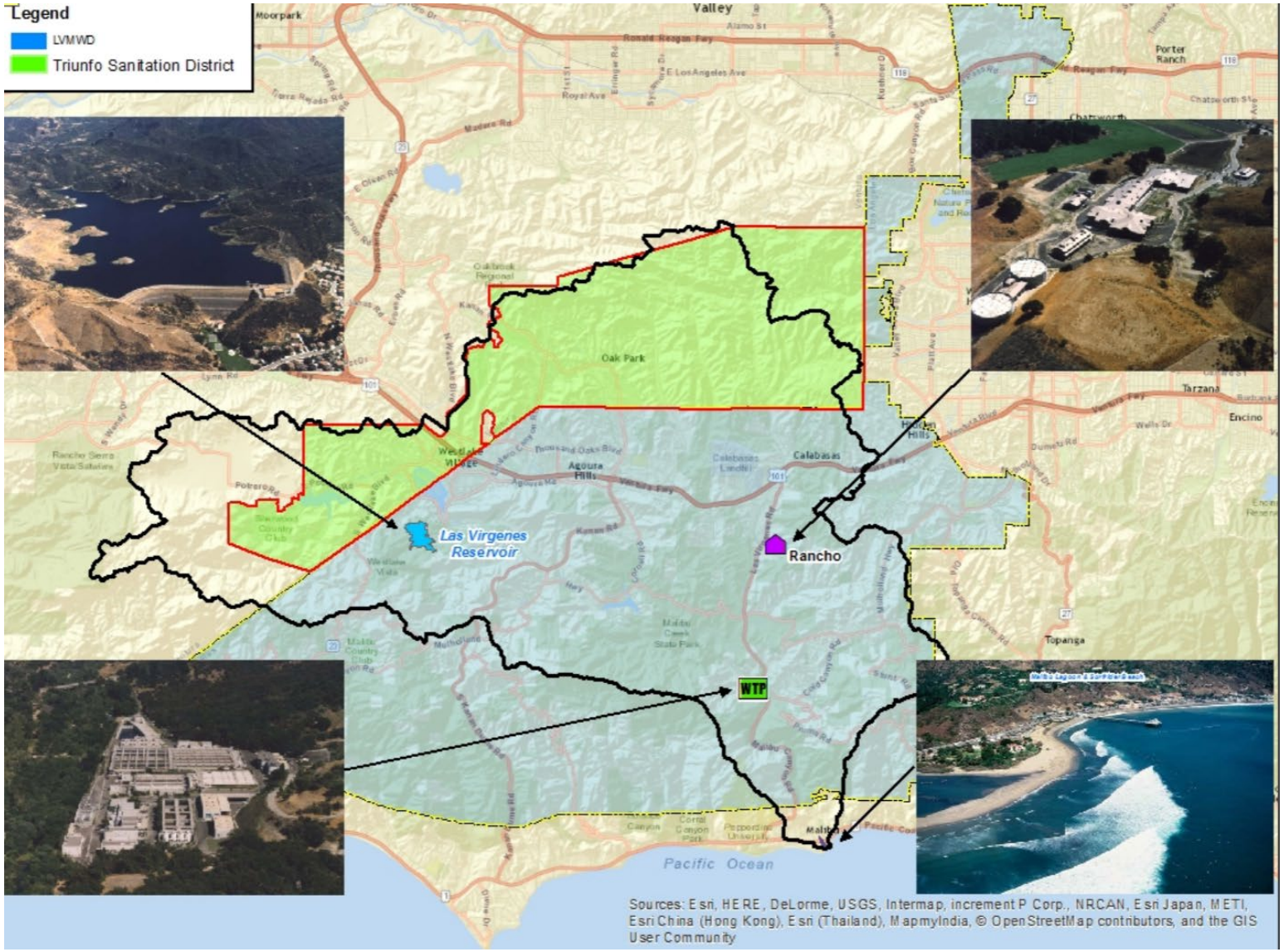
Darrell Johnson

Las Virgenes Municipal Water District

Amos Branch

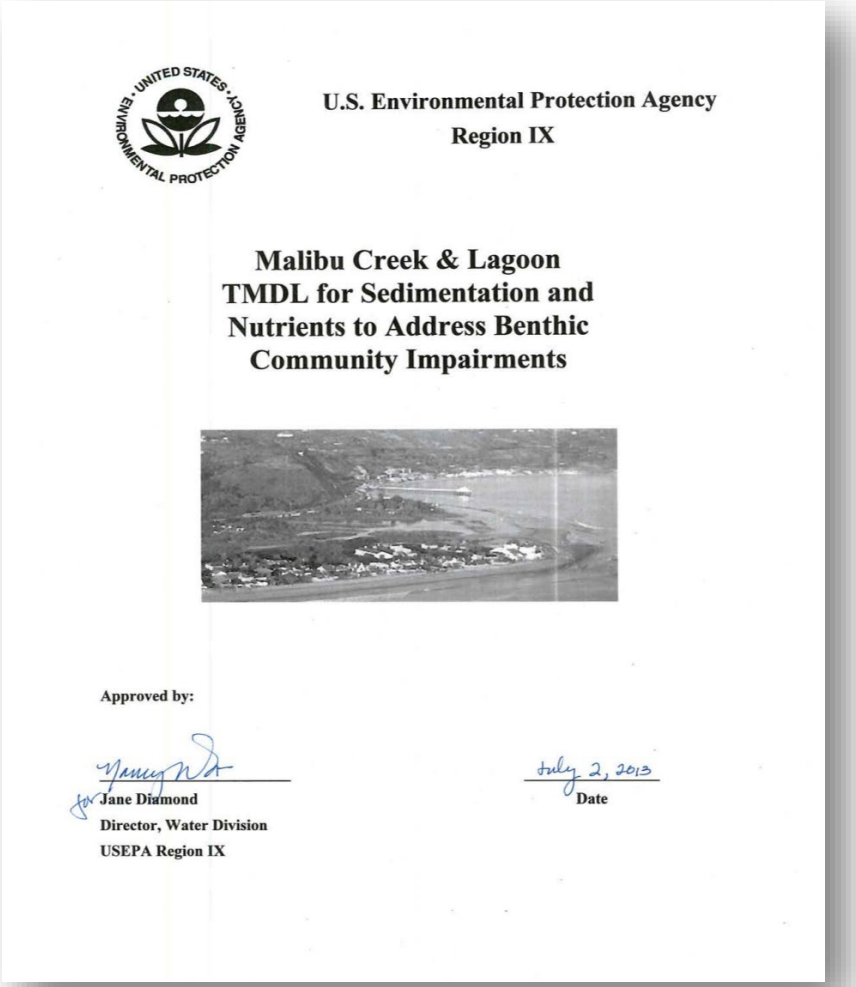
Carollo

Las Virgenes Water District and Triunfo Sanitation District JPA collaboratively protect the Malibu Creek Watershed



In 2013, the EPA established a new TMDL for Malibu Creek with stringent nitrogen and phosphorus limits

- Implemented by LARWQCB May 2017
- Summer Limits (April 15 – November 15)
  - 1 mg/L (total nitrogen) & 0.1 mg/L (total phosphorous)
  - By May 16, 2022
- Winter Limits (November 16 – April 14)
  - 4 mg/L (total nitrogen) & 0.2 mg/L (total phosphorous)
  - By November 16, 2030



U.S. Environmental Protection Agency
Region IX

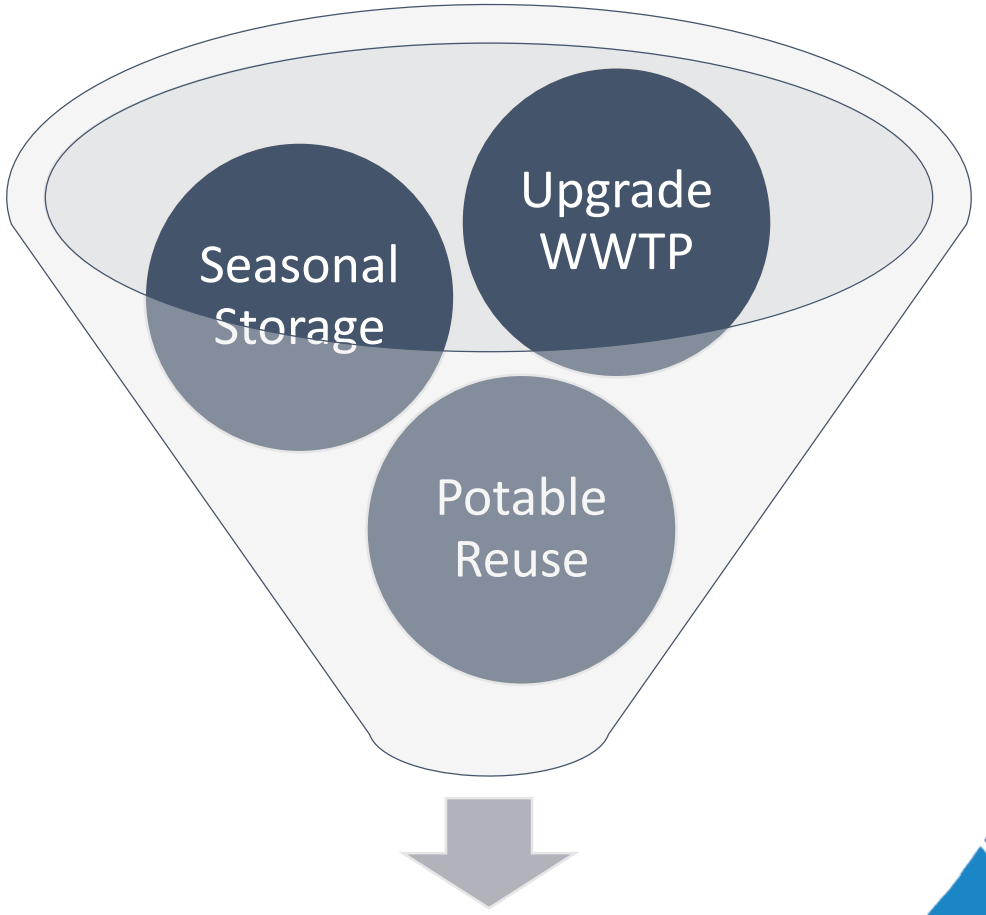
Malibu Creek & Lagoon TMDL for Sedimentation and Nutrients to Address Benthic Community Impairments

Approved by:

Jane Diamond
Director, Water Division
USEPA Region IX

July 2, 2013
Date

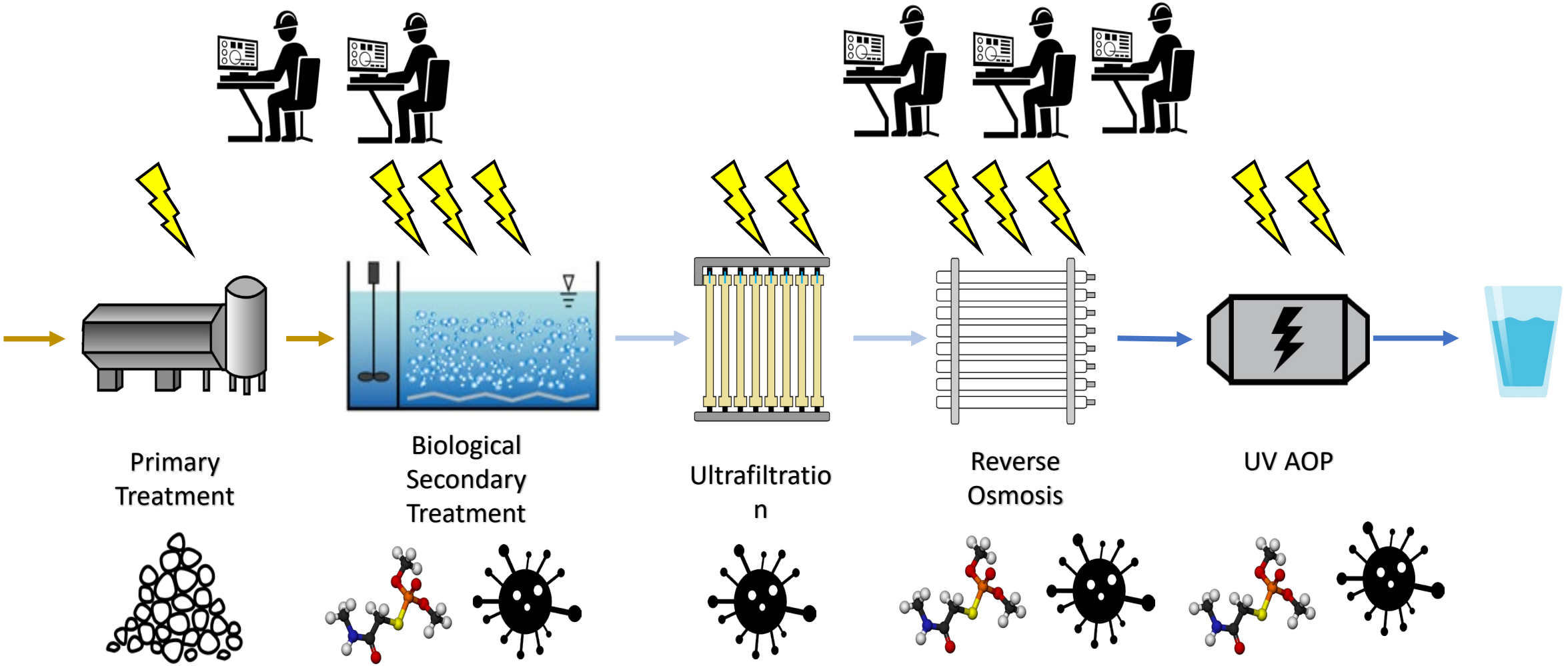
Which of these will best meet the Malibu Creek TMDL and benefit the community at a reasonable cost?



Potable Reuse via Reservoir Water Augmentation

PURE WATER PROJECT
LAS VIRGENES-TRIUNFO
Bringing Our Water Full Circle

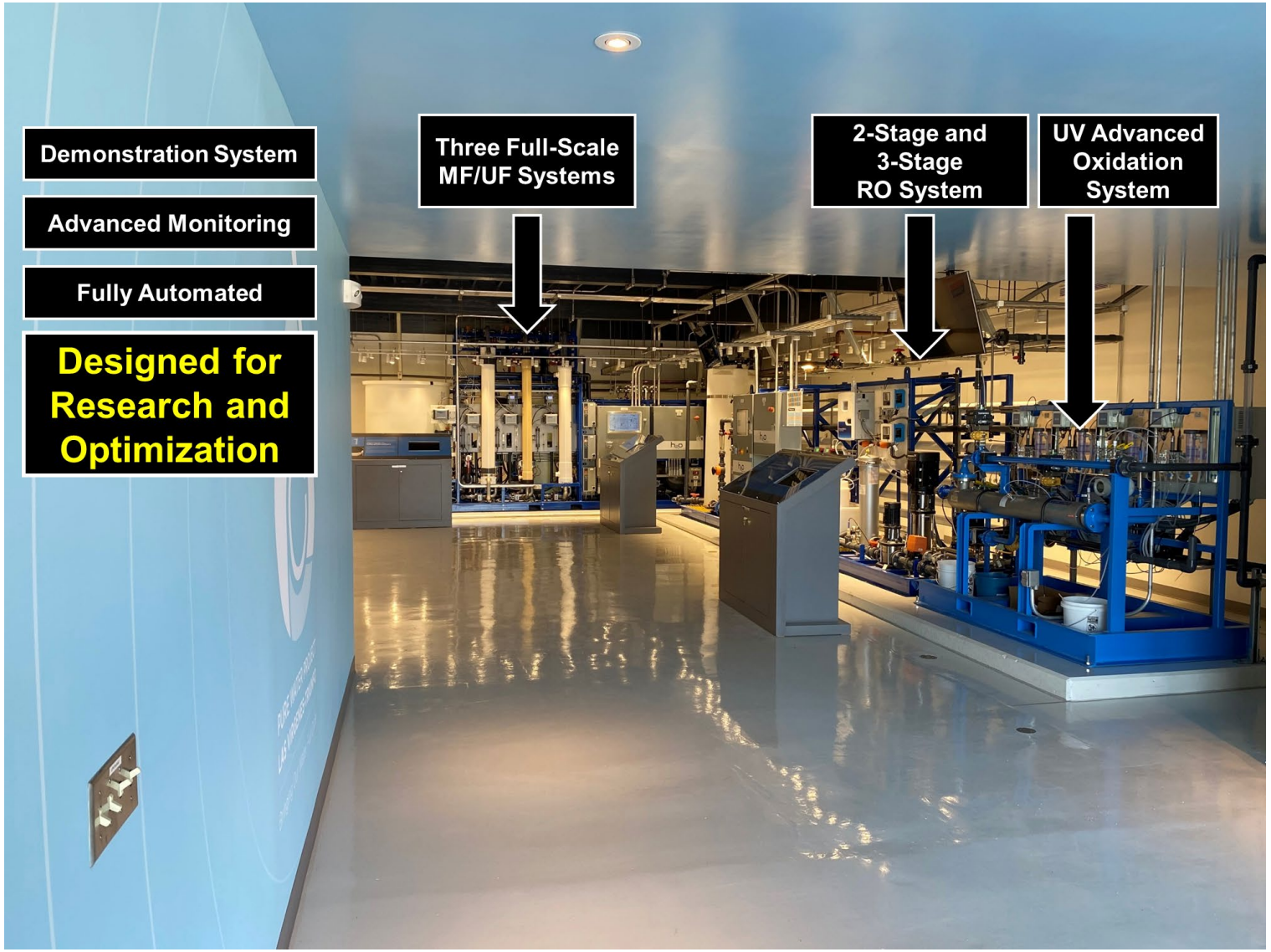
JPA Taking a Holistic Approach to Energy Use and Water Quality



Tapia Water Reclamation Facility

Las Virgenes Triunfo JPA Pure Water Demonstration

Las Virgenes Triunfo JPA Pure Water Demonstration



- Three Full Scale MF/UF
- Run in Parallel (same feed source)
- Independently Monitored and Controlled
- Now almost 3 years of 24/7 operating data

Future Supply Actions Las Virgenes AI Research Scope

- Task 1 – Model Predictive Control to Reduce Energy Consumption at WRFs
  - Quantify the Potential for Energy Savings
  - Investigate the Utility of Ammonia Control to Reduce Addition for Chloramination
- Task 2 – Pathogen Based AWPF Control
  - Investigate Alternative Virus Surrogates
  - Investigate the Feasibility for Semi Autonomous Operation to Enhance Energy Savings

Project Partners

PURE WATER PROJECT
LAS VIRGENES-TRIUNFO
Bringing Our Water Full Circle

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

carollo

YOKOGAWA

Later Contributors

IOSight

VTScada by Trihedral

NORI

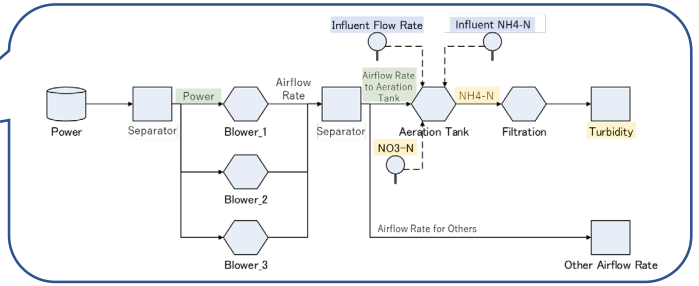
Reducing Energy Use While Maintaining Water Quality in the Biological Secondary Treatment Process

- Nutrients and Performance →
- Airflow ↓
- Power ↓

ML/AI for WRF Optimization – Data Driven Model Optimization (DDMO)

- Take training data from Tapia WRF
- Set goals based on nitrogen species targets and determine optimized blower operation mode.
- Predict aeration savings
- Compare DDMO output with Biowin simulation of the same plant.

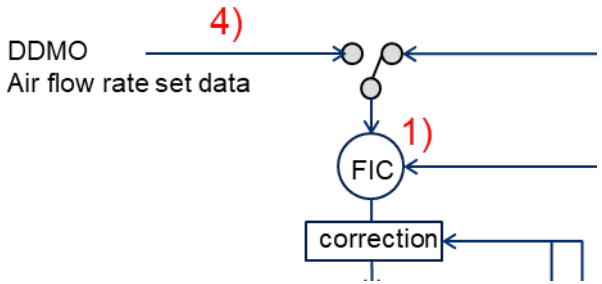
a. Install initial DDMO model.



b. DDMO derives optimum airflow rate (every 15 minutes, for example).

Optimum airflow rate is derived in terms of influent water qualities so that effluent water qualities are tolerant of the discharge limitation.

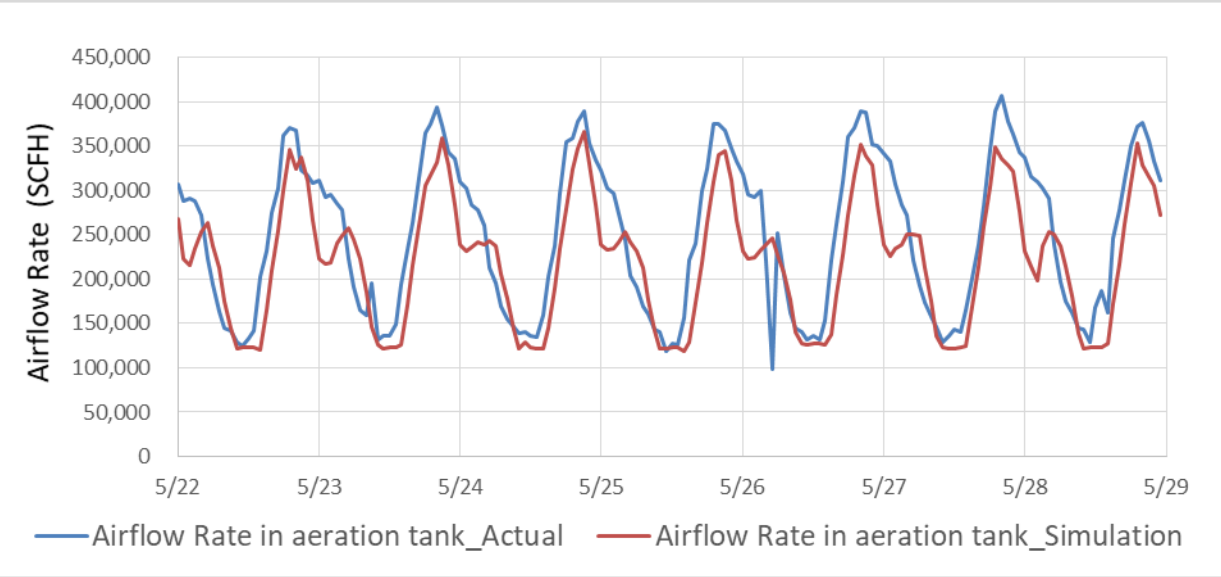
c. Provide the optimum airflow rate (=manipulated value) to control system.

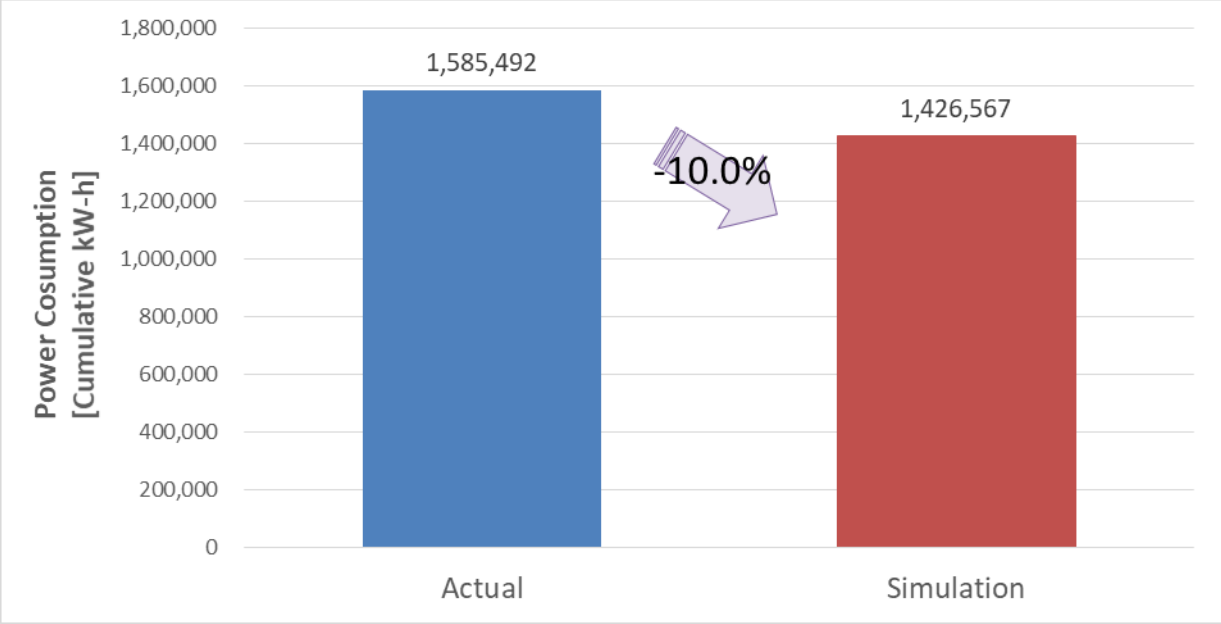


d. The DDMO model installed is updated by relearning data (every 1 week or operation change, for example).

<Equations in DDMO model>
Effluent NH4-N[t] = coef_1*influent water + coef_2*influent NH4-N + …
coef_1, coef_2, … are updated automatically.

DDMO Initial Results – Offline Evaluation on Historic Data

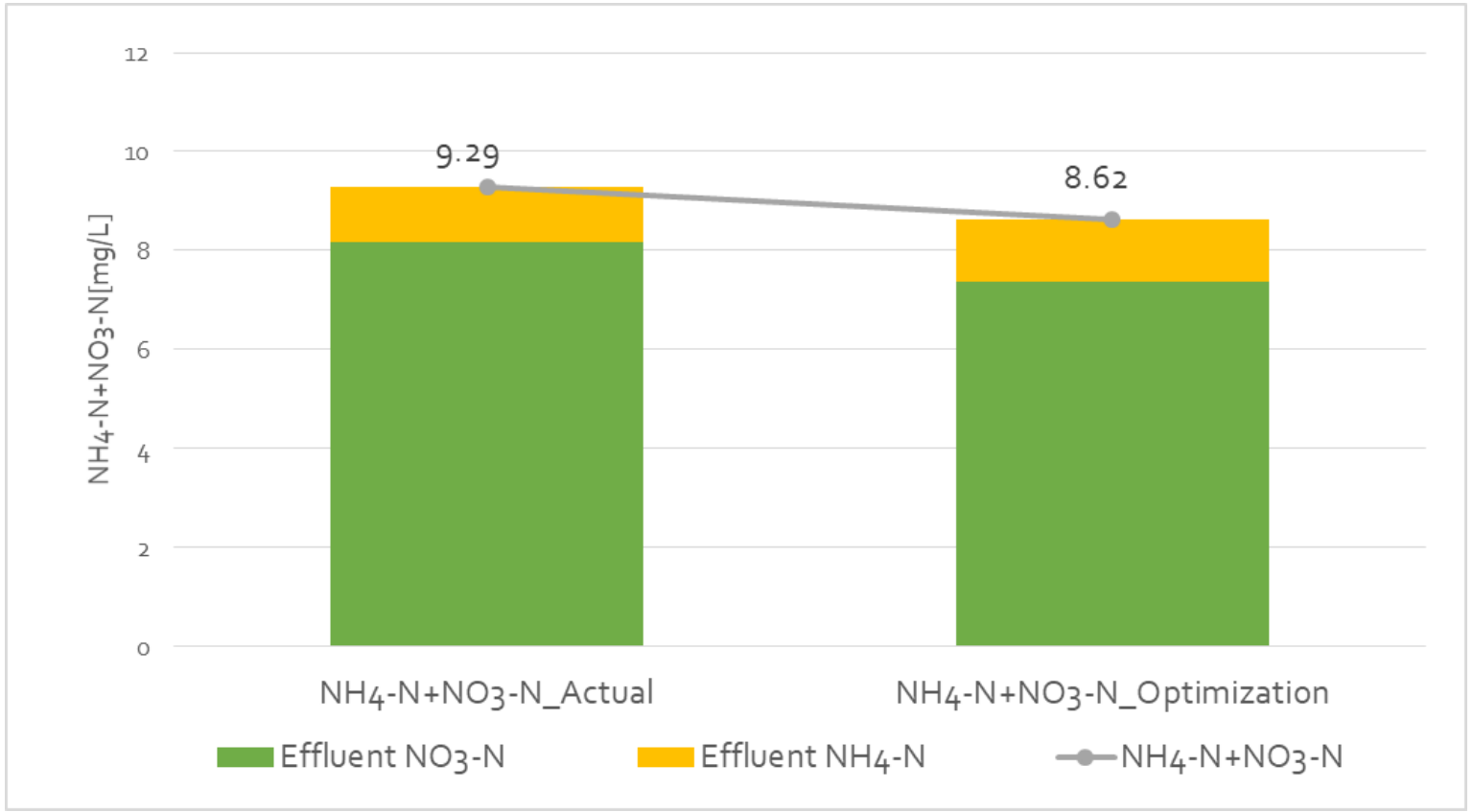




- Use historic data to train and then simulate a period.
- Simulated optimum air control vs actual to achieve ammonia effluent goals
  - 10% potential energy savings.
  - Marginal increase in effluent ammonia.
- Also simulated with optimization goal of reduced ammonia (30%), resulted in 2.7% energy increase (as expected).

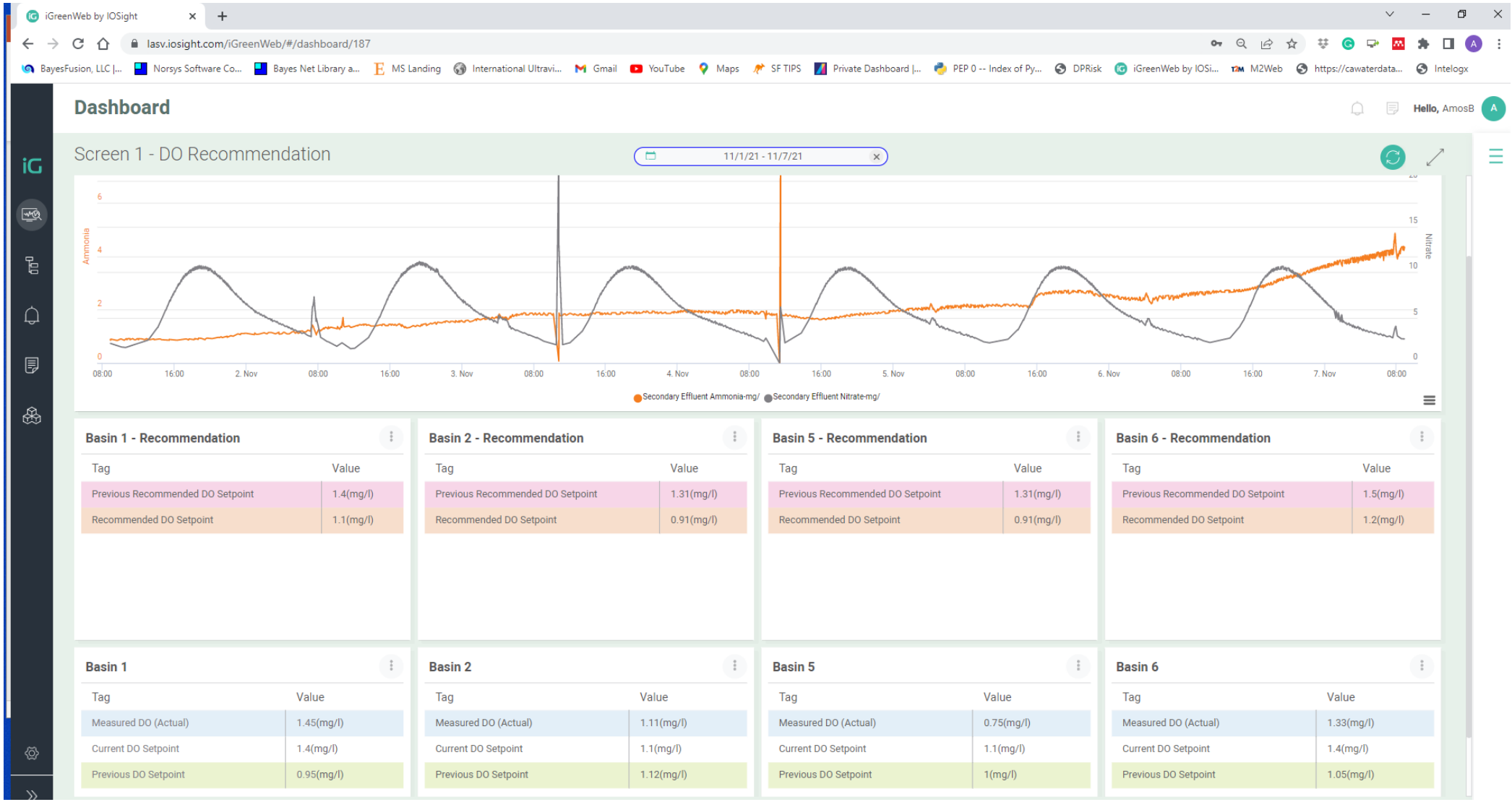
DDMO Initial Results – Offline Evaluation on Historic Data Revisited

- Revisited with new blowers (September 2020)
  - Still potential for 10% energy savings
  - Marginal increase in effluent ammonia
  - Slight reduction in TN
- Verify and validate by using DDMO recommendations to adjust blower setpoints according to the optimized simulation results.

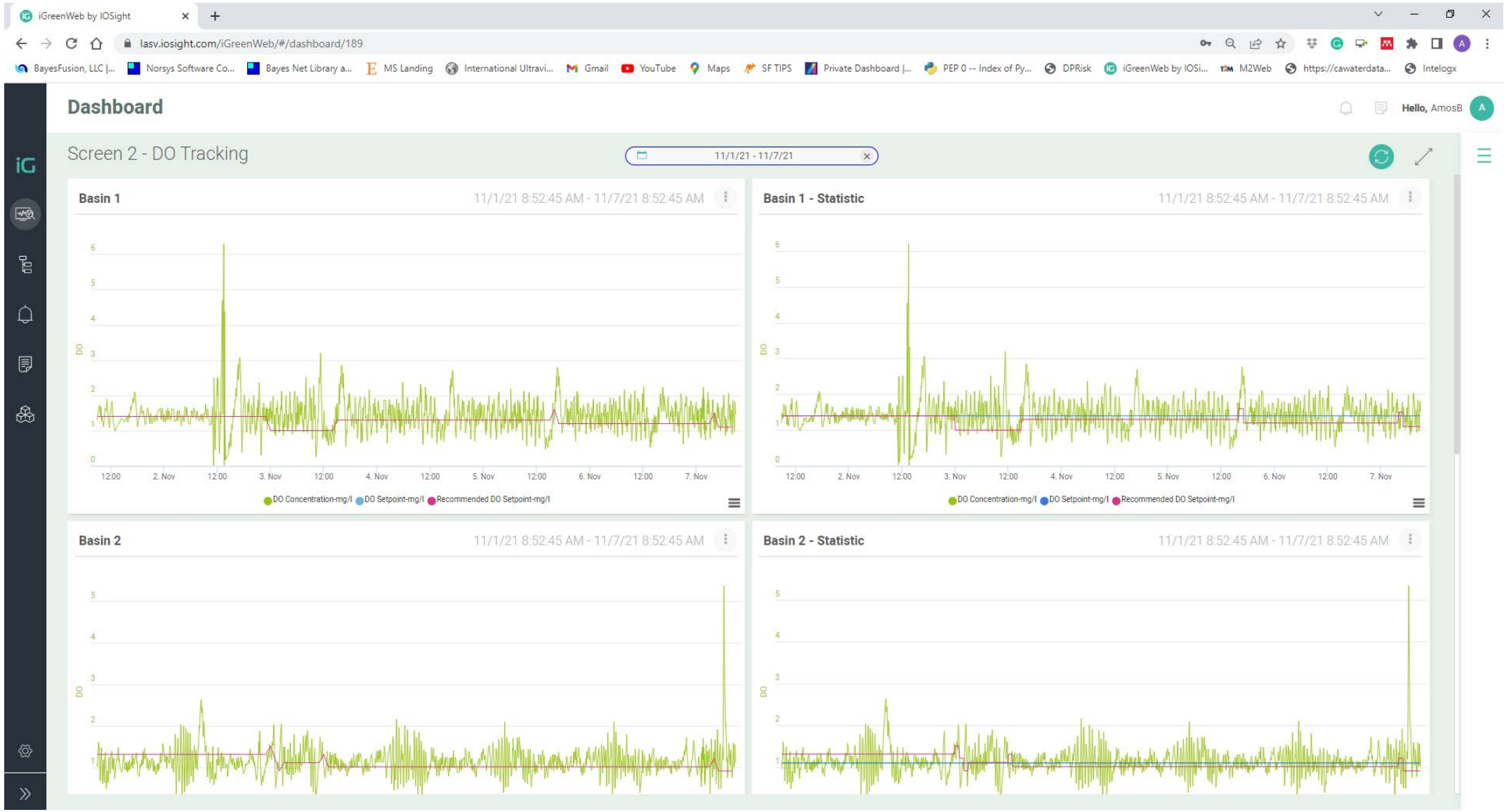


Future Work Kickstarted by This Initial Project – Real Time Interface

- Predictions by Yokogawa for optimized DO setpoint
- Data transfer via IOsight iGreen and
- Setpoint changes by ops staff.

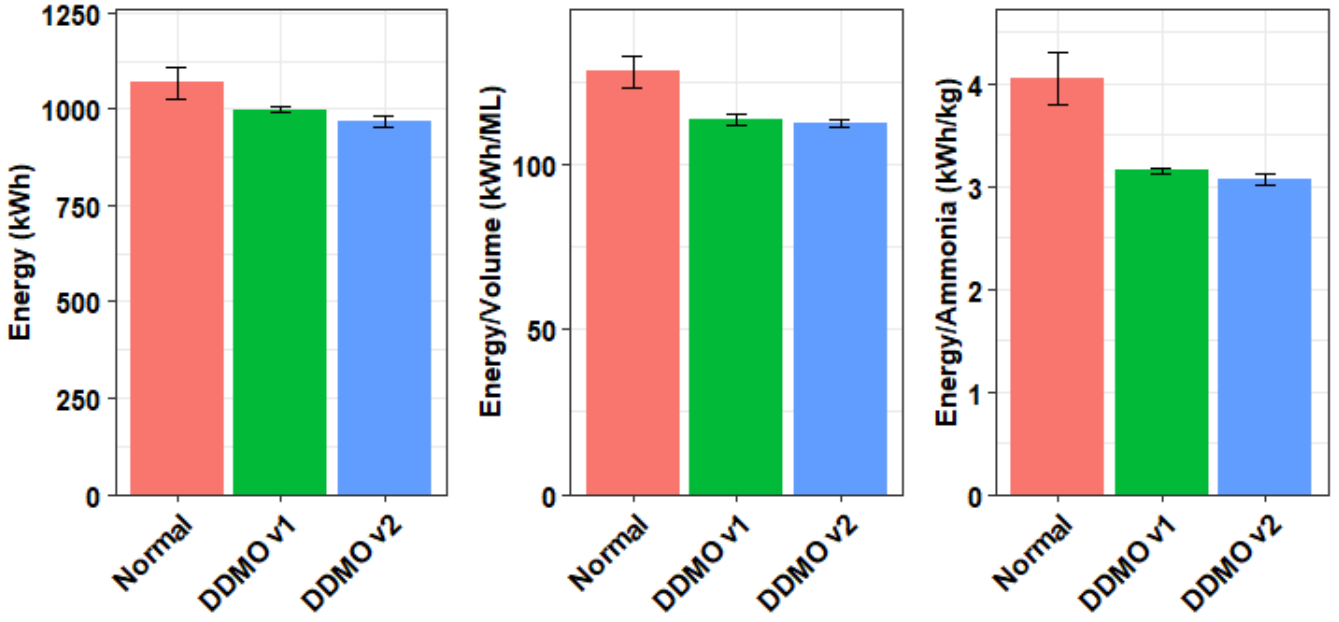


Real Time Tracking of Adjustment Effectiveness



Significant Improvement with No Additional Hardware Compared to the Status Quo

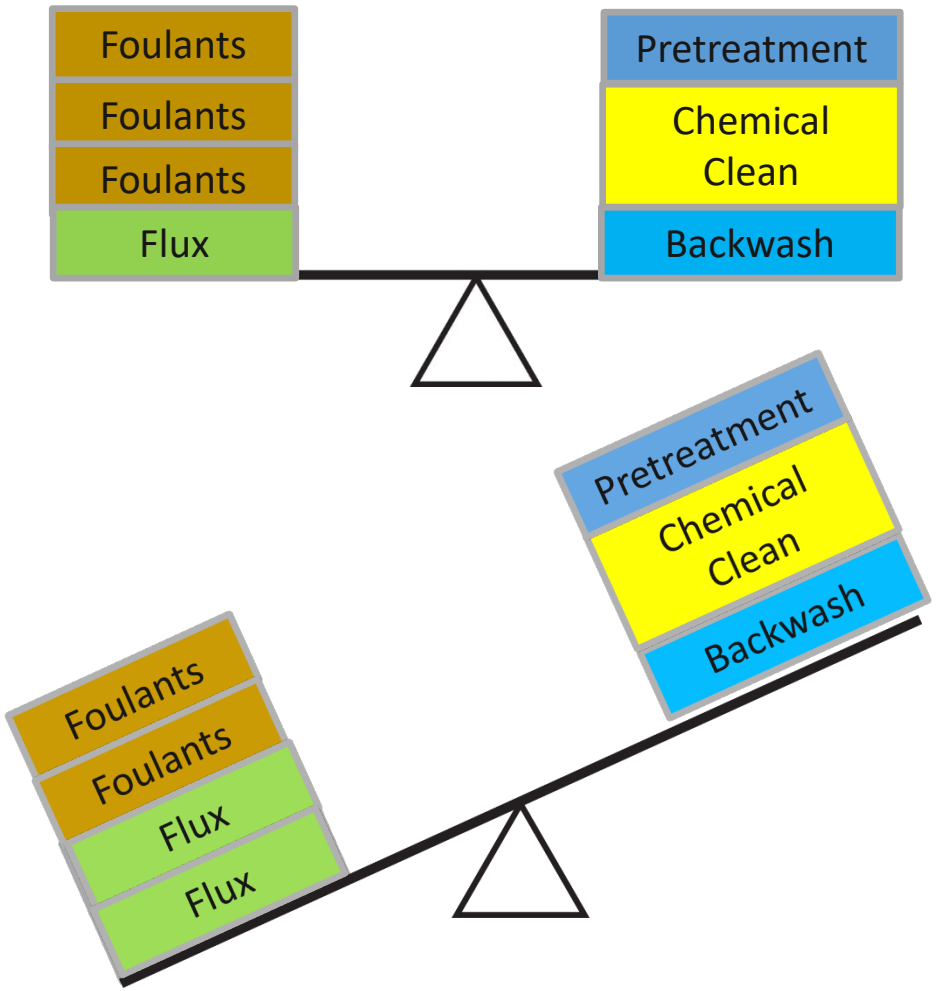
- A ML based solution kickstarted from the foundations of this grant for aeration optimization was implemented.
- The solution required no hardware changes and was set up in the existing data management program (IOsight).
- Modest but significant savings relative to implementation costs could be achieved.
- Potential for follow up testing and evaluation post Tapia SCADA upgrade.



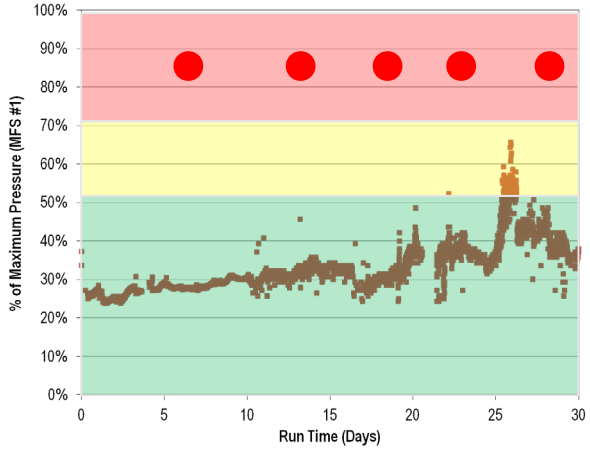
Moving Down the Treatment Train to the AWPF MF/UF

- Max Total Feed Flow 100 gpm
- Open-platform - 3 vendors with independent monitoring and operation
  - UF1 - Dow SFD-2880XP (0.03 µm)
  - UF2 - Pall UNA 620A (0.1 µm)
  - UF3 – Toray HFUG Type 2020AN (0.01 µm)
- UF Feed Chemical Dosing
  - Chloramine (Ammonium Sulfate + Sodium Hypochlorite)
  - Flow Paced Set Point – 2.5 – 3.0 mg/L
  - Targets –
    - 2 – 2.5 mg/L total Cl2 in UF filtrate
    - 0.5 mg/L free ammonia in UF filtrate

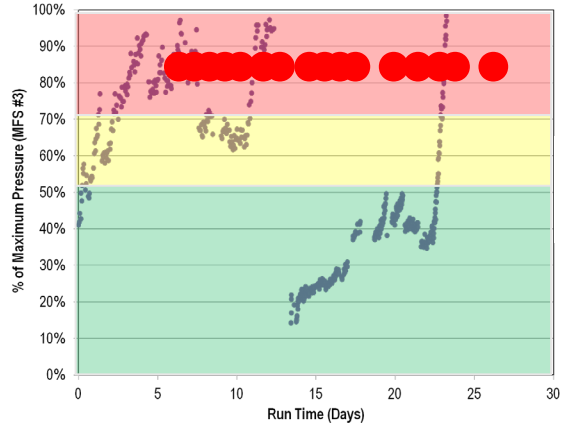
Micro- and Ultra-Filtration Sustainable Operation



TMP

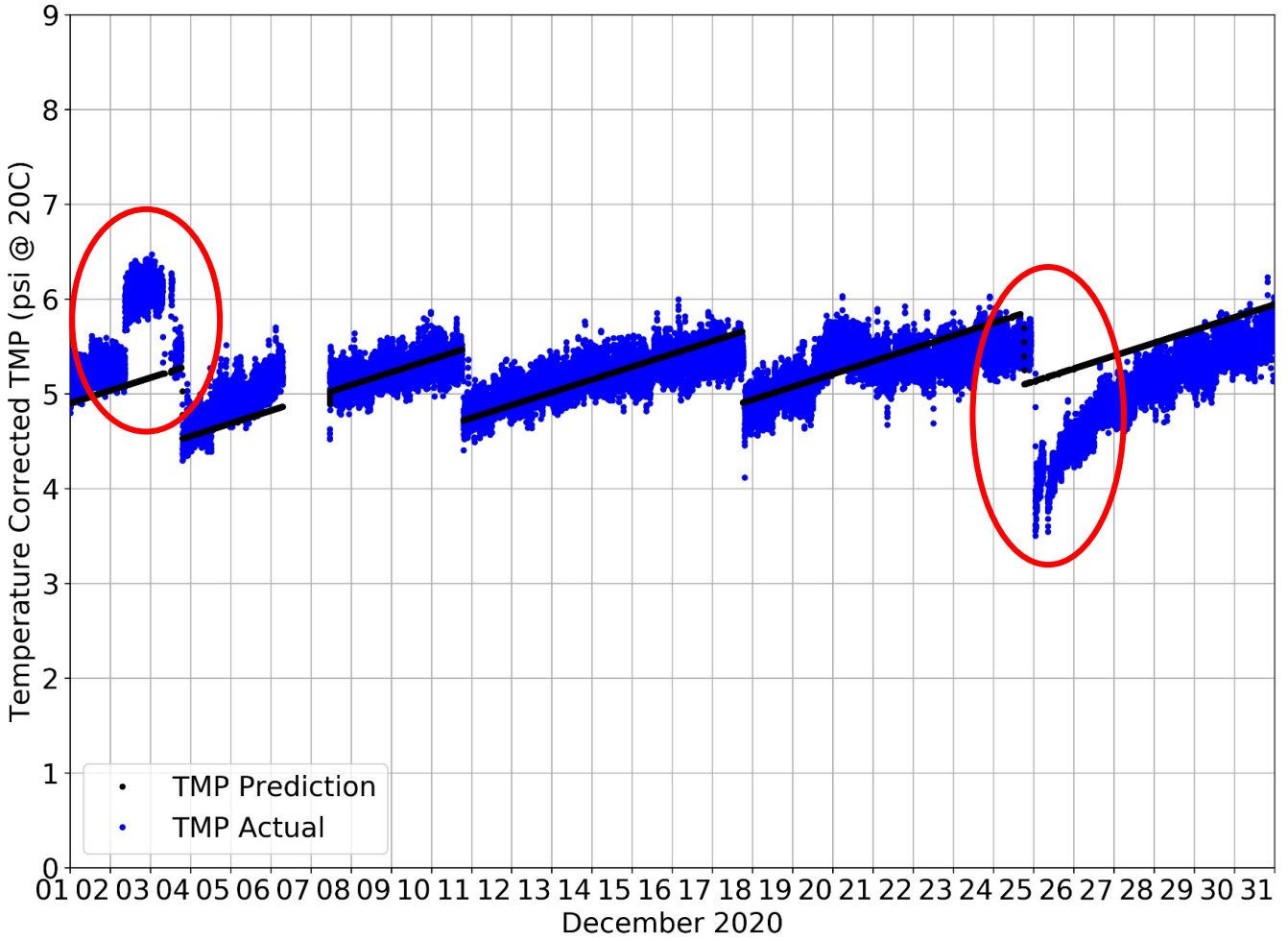


TMP



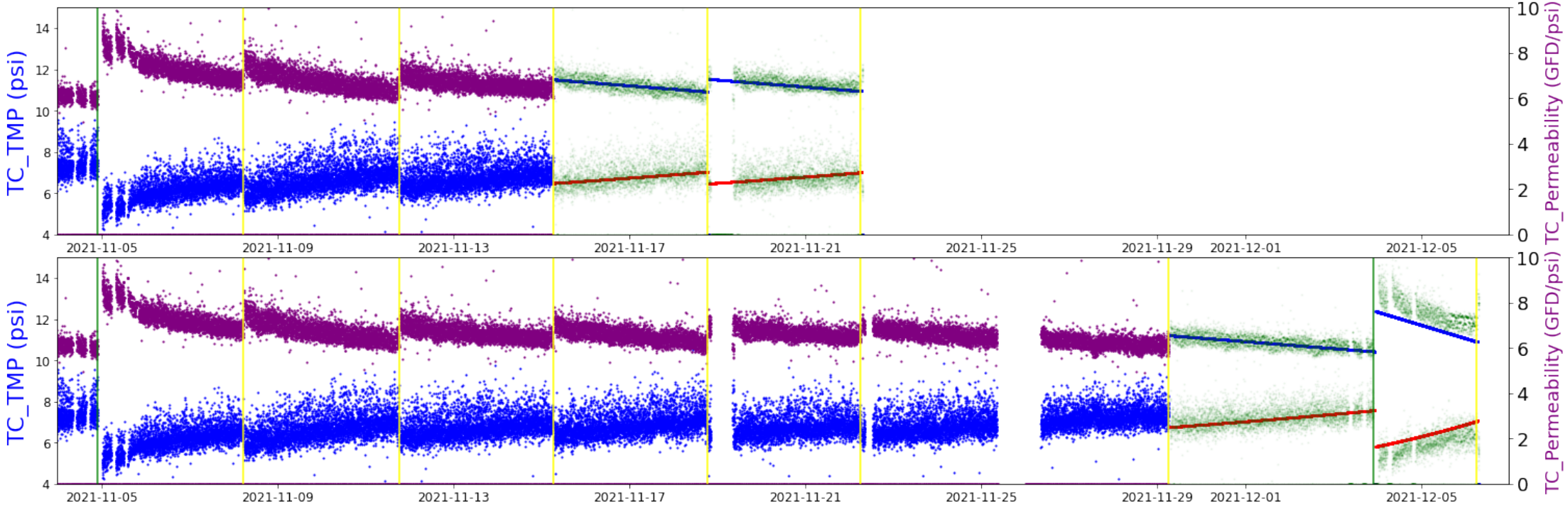
Initial Work, Offline Data Analysis and Blind Prediction of the Future

- Explored at desktop-scale.
- 1-month blind trial.
- Generally accurate except for two excursions.
- These excursions were caused by changes in cleaning procedure that were not communicated to the model

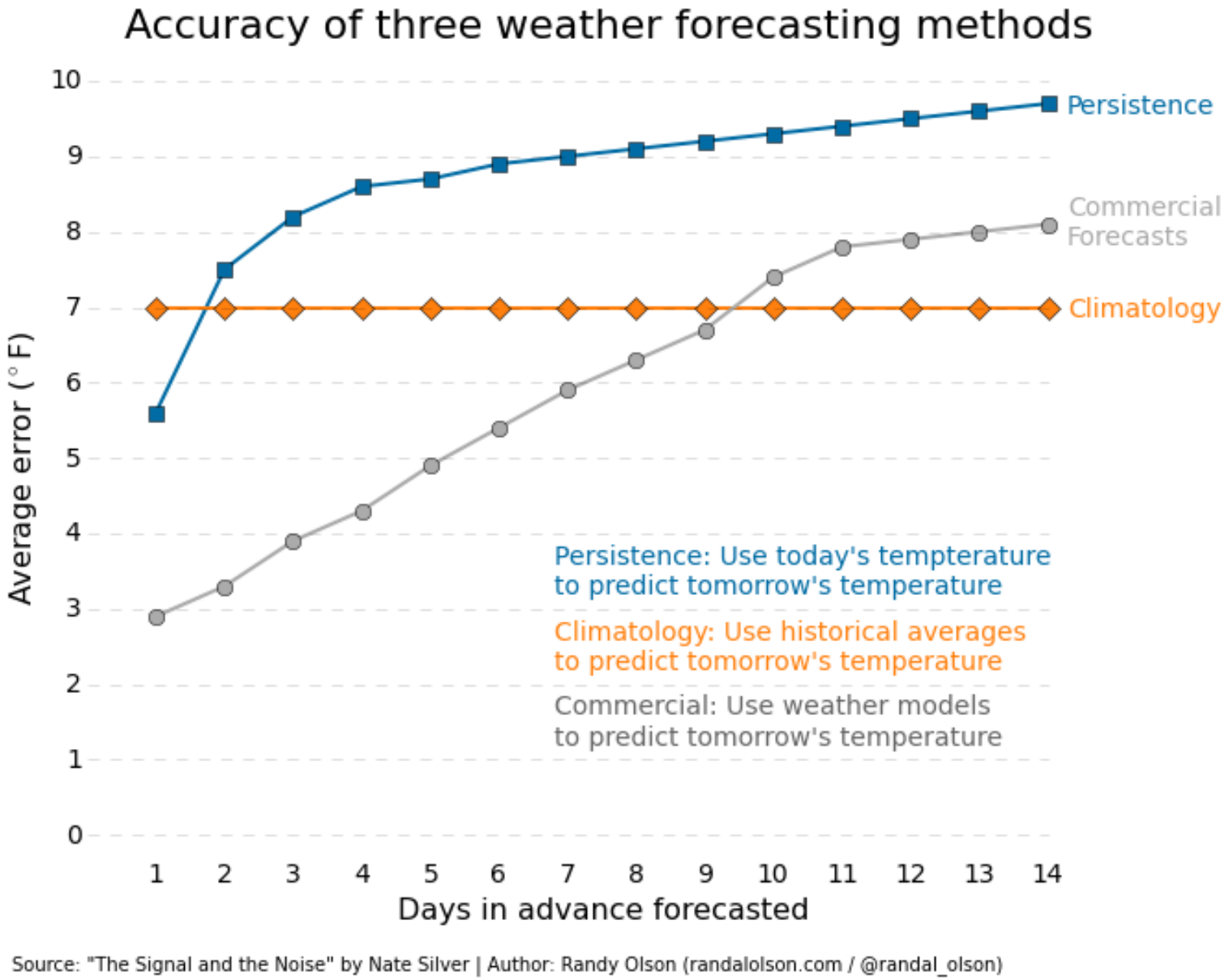


Initial Modelling Work Revised and Improved.

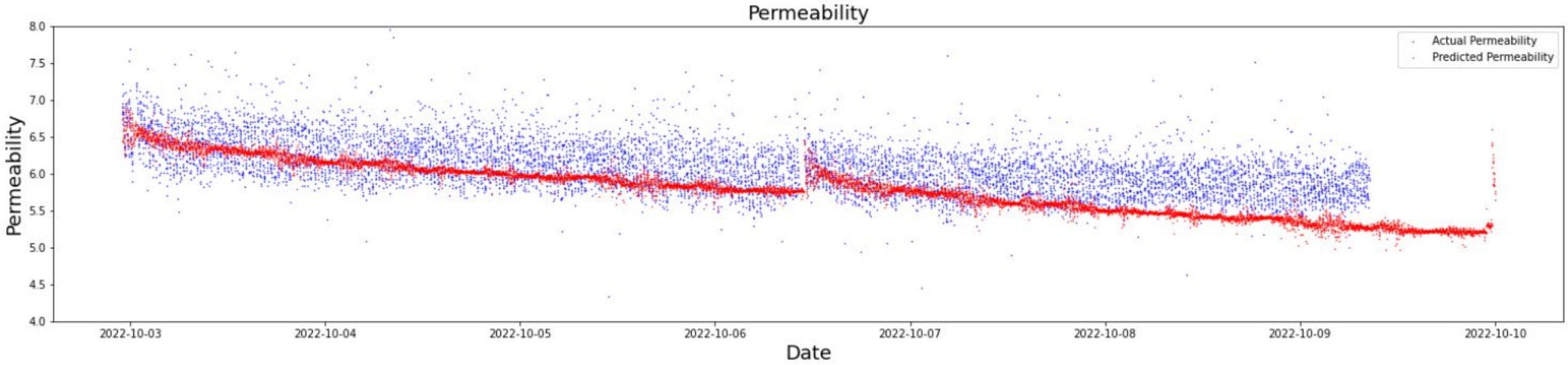
- Model 1 = fouling rate during operation
- Model 2 = change in fouling during clean
- Model 1 + Model 2 + cleaning schedule = long-term forecast!



Making accurate predictions gets more difficult further into the future.

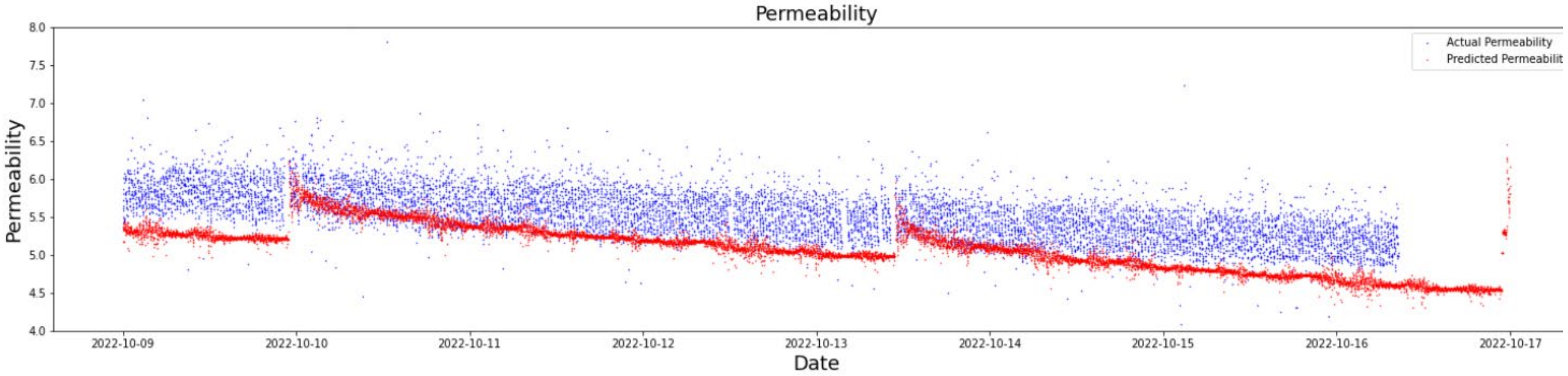


Predictions: first week



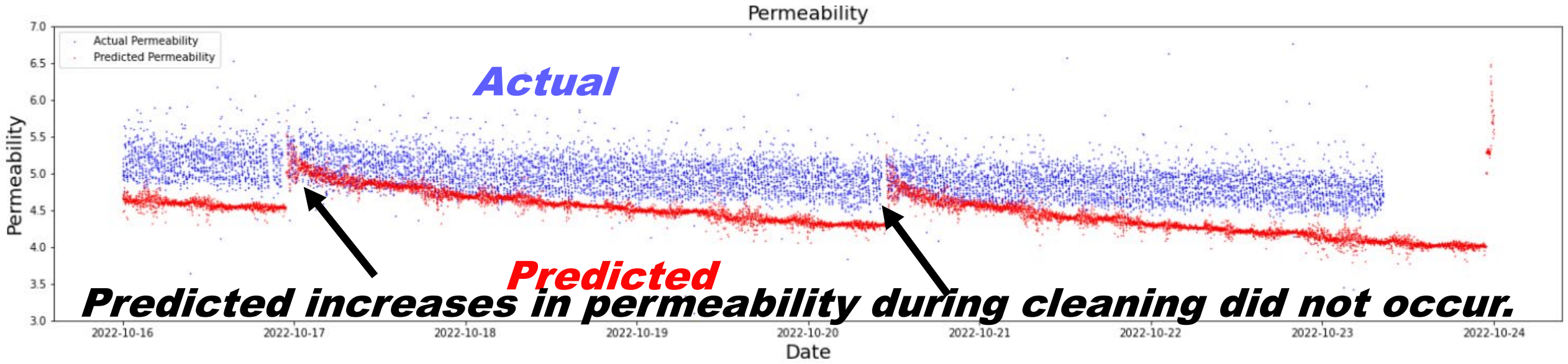
MAPE (%)	RMSE
4.84	0.31 gfd/psi

Predictions: second week



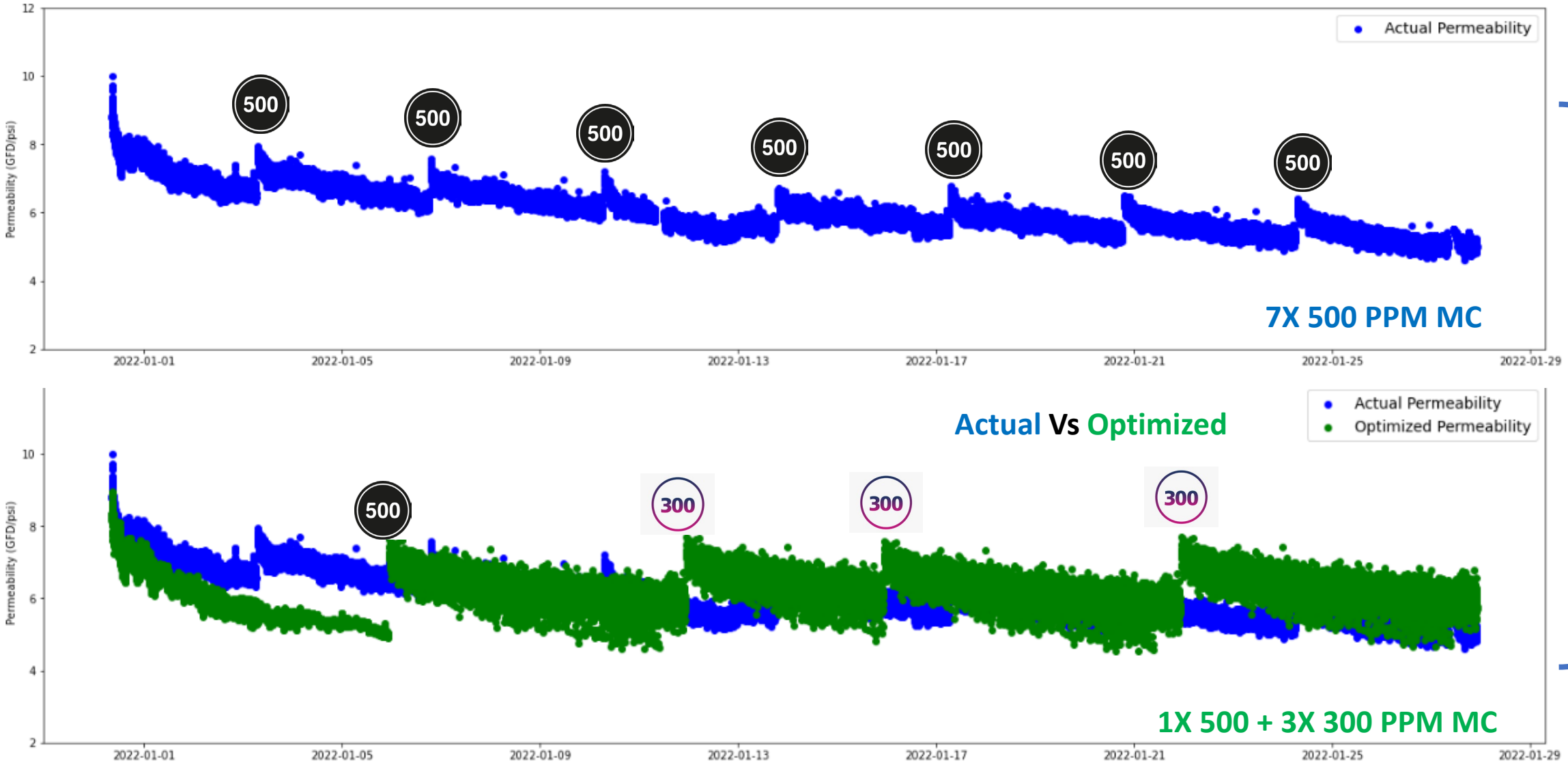
MAPE (%)	RMSE
7.55	0.44 gfd/psi

Predictions: third week



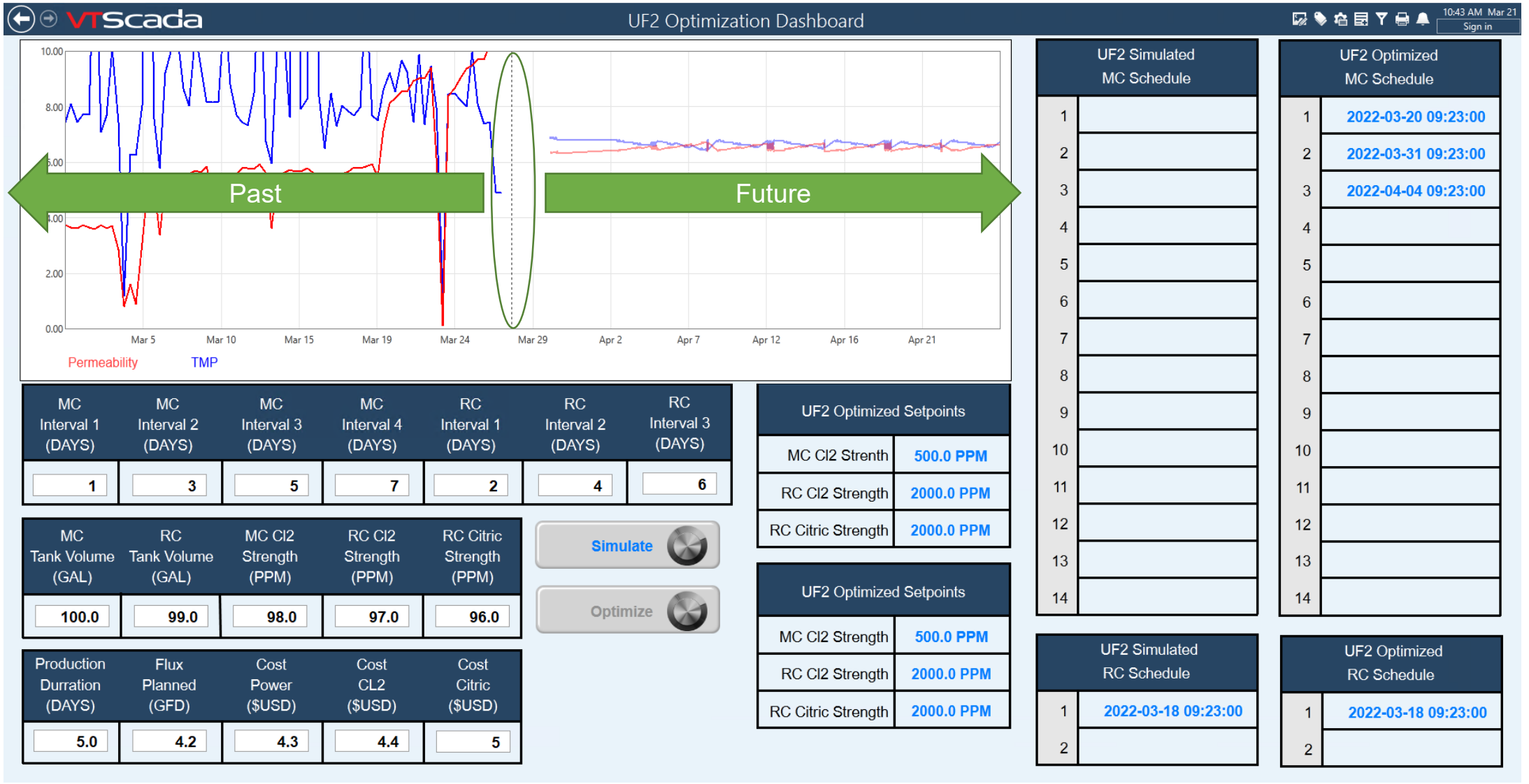
MAPE (%)	RMSE
9.49	0.44 gfd/psi

Most Promising Optimization – Chemical Usage

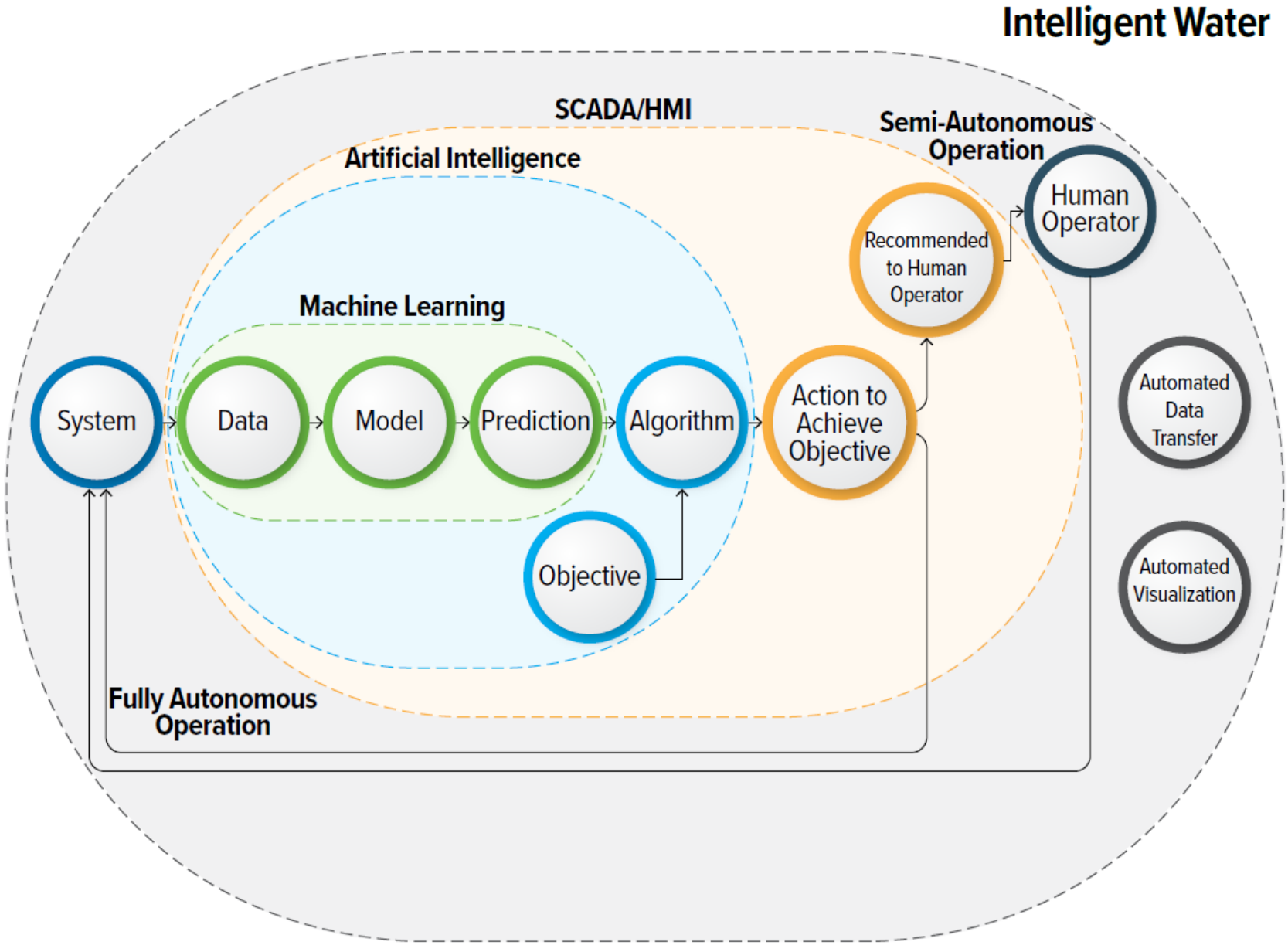


60% Less Cleaning

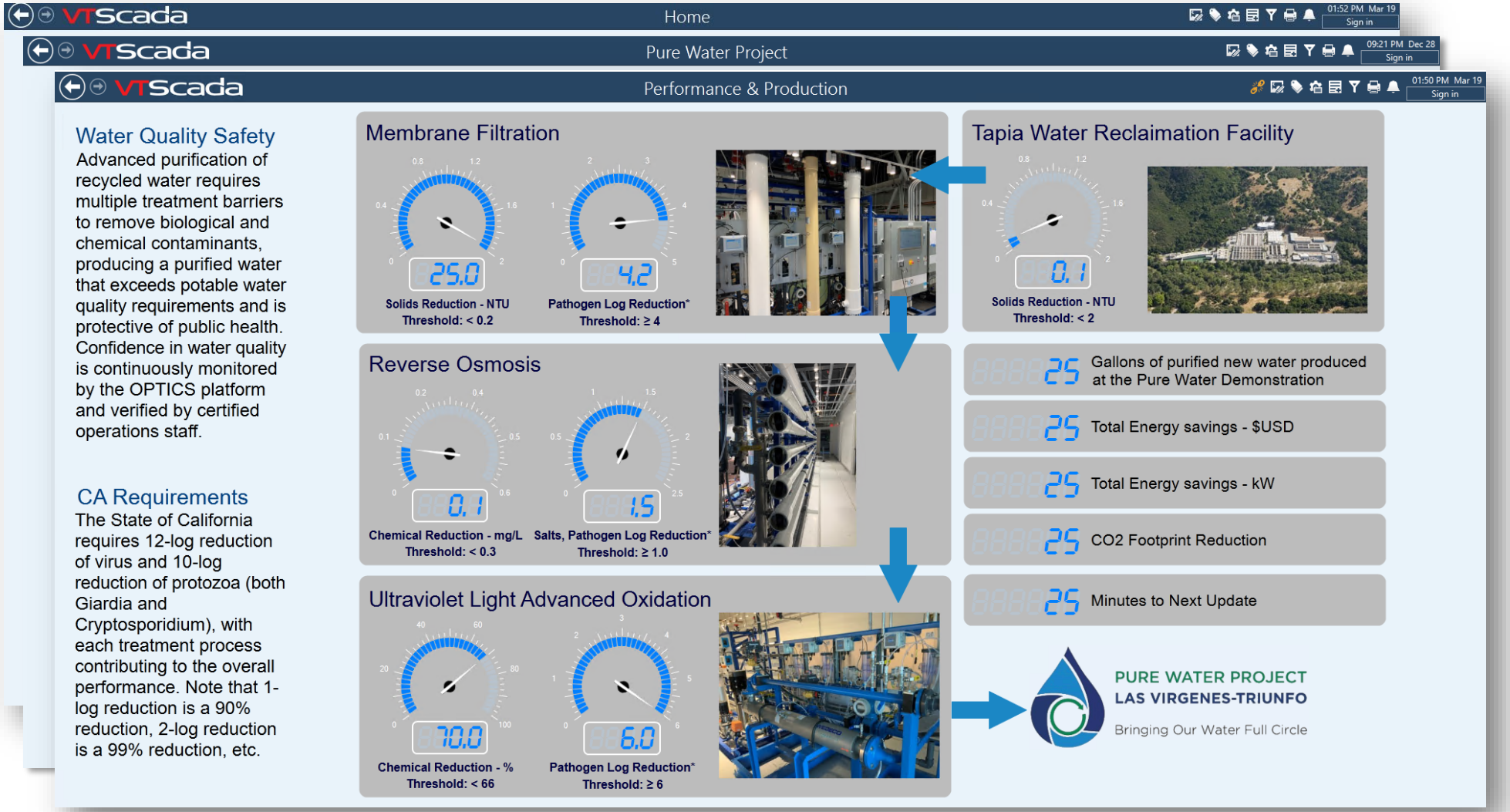
What if interface – What will occur if I operate like this, How and when should I clean?



Where do we think we are headed?

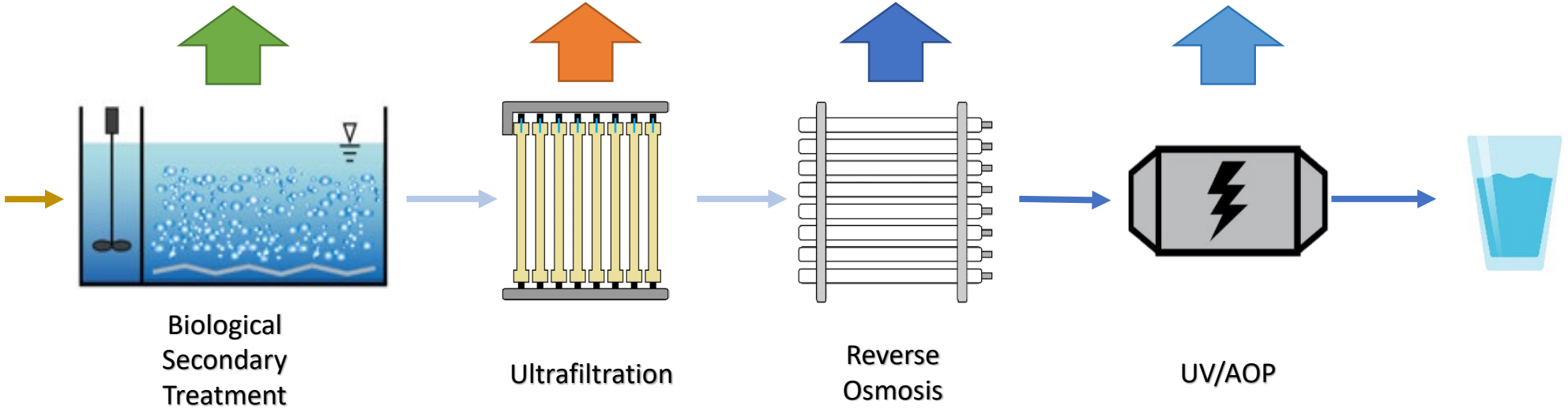


The FSA Research Activities Paved The Way for Development of a SAO Interface



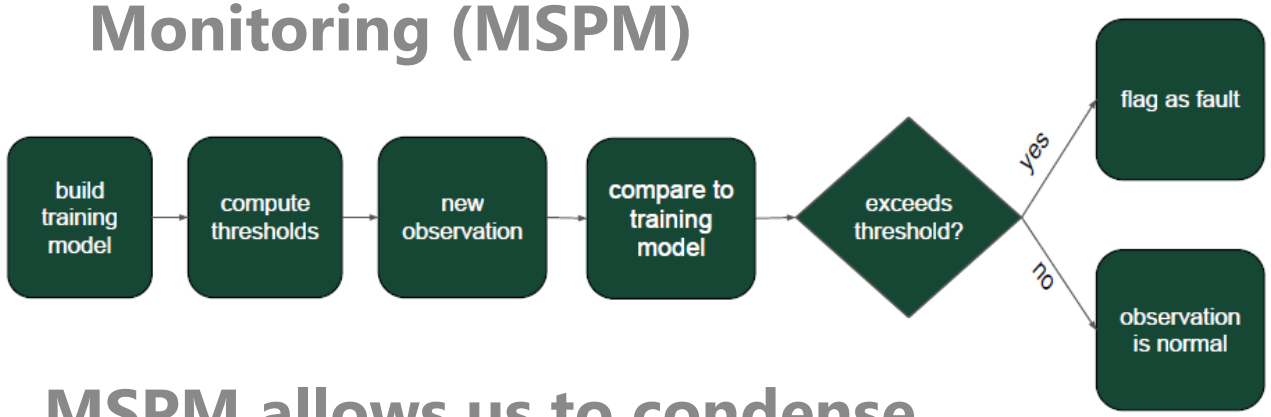
What else is in the pipeline stemming from the FSA project?

Pilot/Full-Scale Demonstration study	METI ('21)	USBR ('22)	USBR ('23)	NAWI ('23)
Desktop Feasibility study	MWD & METI ('19 & '20)	METI ('21)	USBR ('22)	NAWI ('22)

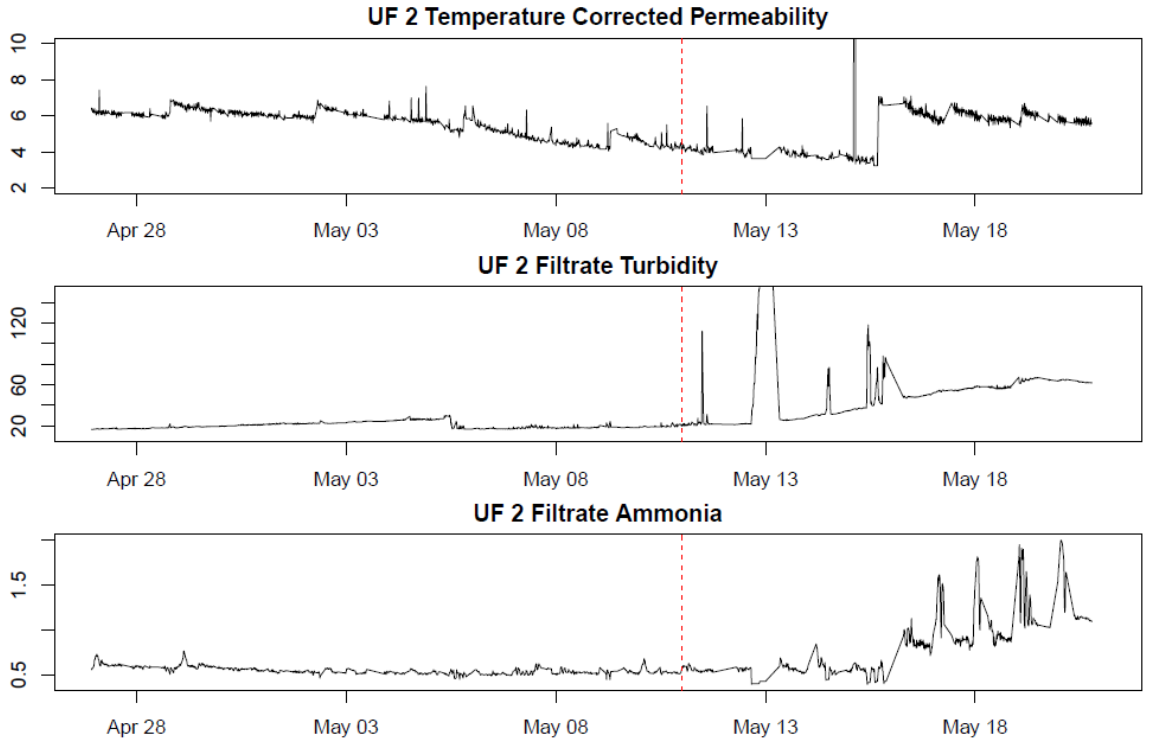


Developing a Method for Real Time Detection of Abnormal Behavior

Multivariate Statistical Process Monitoring (MSPM)

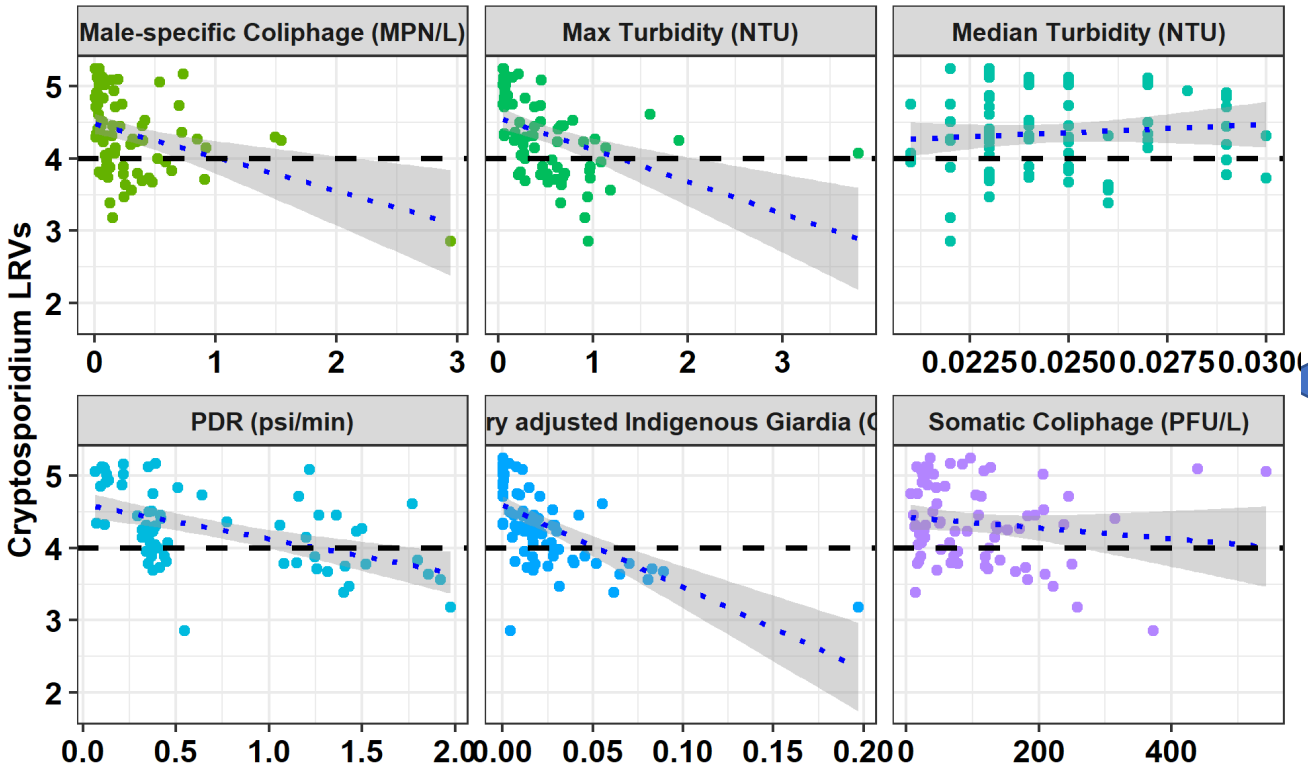


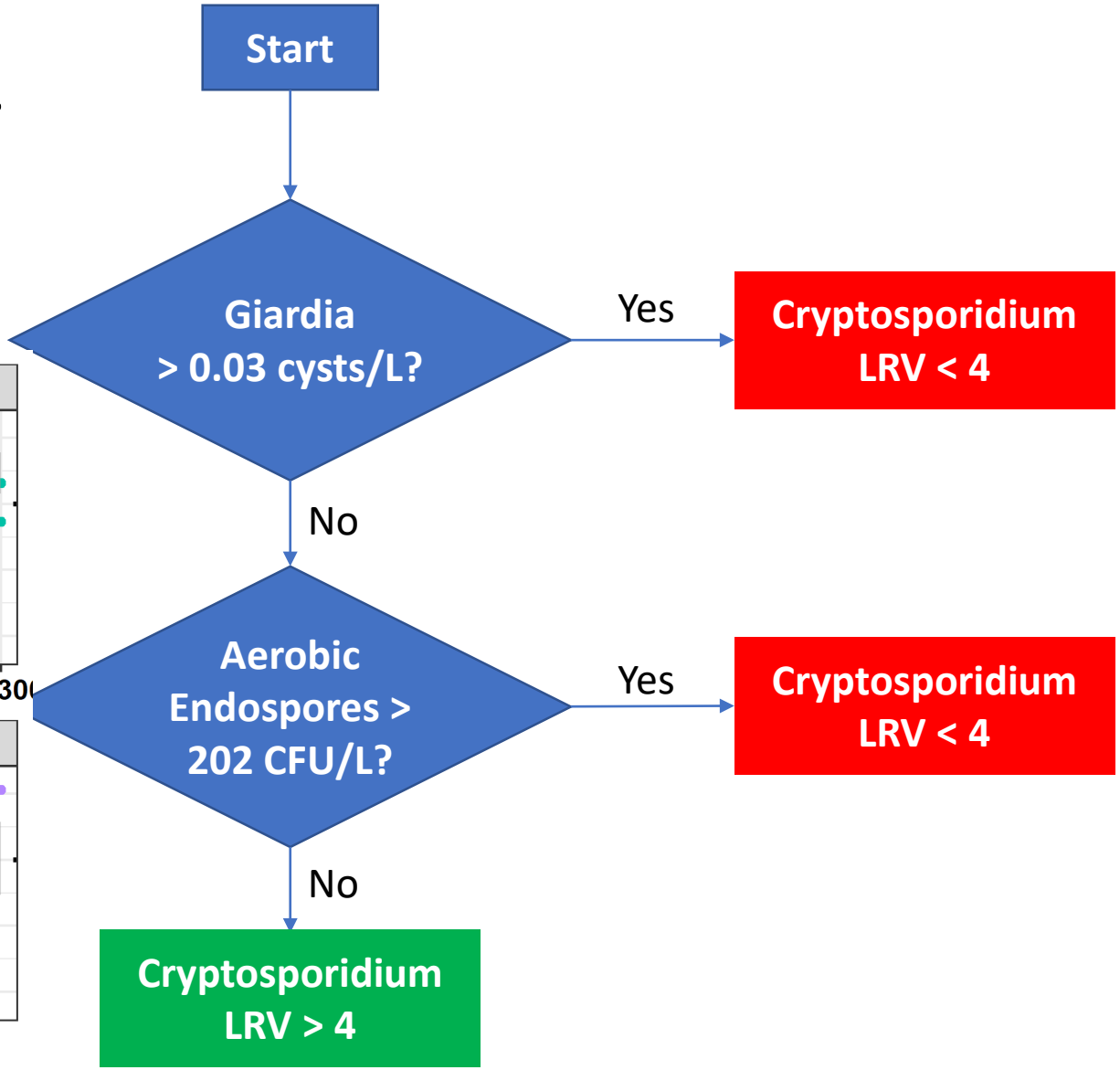
MSPM allows us to condense information from several variables into 2 monitoring statistics (T2 and SPE)



Initial Decision Trees for Better Pathogen Reduction Verification (C5.0Rules)

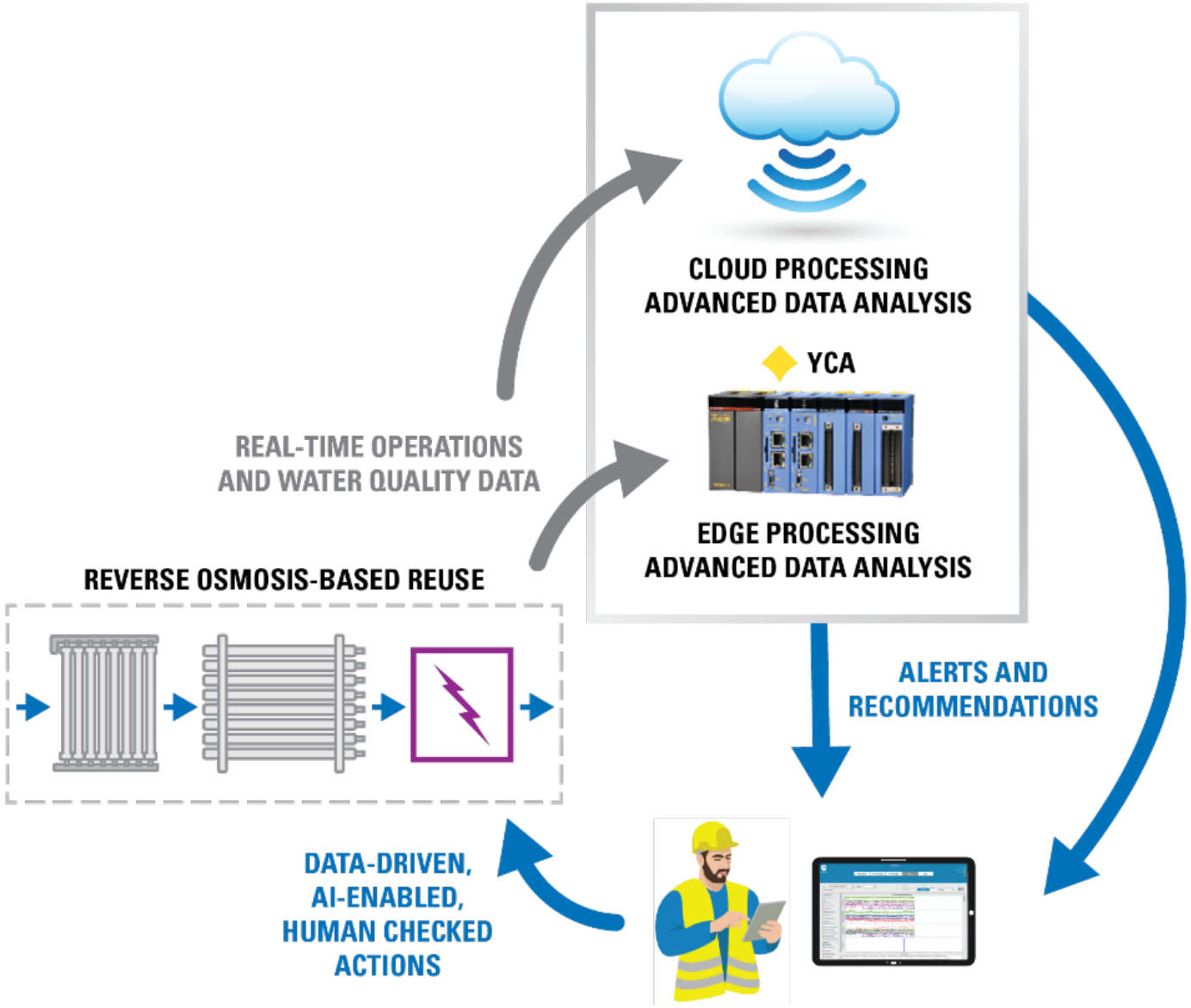
- Direct correlation exists but strength is weak.
- Machine learning shows promise to improve prediction significance across multiple variables





Research to Date Stemming from Initial FSA Efforts Shows Promise

- Regulatory Confidence
- Operational Support
- Data Security



Questions and Discussion