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The Search for Your Digital Twin; A Utility's Journey Through Intelligent Water Systems

Chris Maher, Senior Operations Analyst

74th Annual KU Environmental Engineering Conference

Clean Water Services

Lecture Outline

- Clean Water Services
- Intelligent Water Systems
- DIKA
- Data Visualization
- Applications for Advanced Data Analytics
- Obstacles
- Digital Twins

CLEAN WATER SERVICES

- Suburban, Industrial, Commercial, Agricultural Area West of Portland, OR
  - Pop. 600,000
- Tualatin River Watershed
- 4 WRRFs
- Watershed Based NPDES Permit
  - Wastewater, Stormwater, Watershed Management

CWS Water Resource Recovery Department (WRRD)

- 2 advanced treatment facilities
  - Rock Creek
  - Durham
- 2 smaller facilities
  - Hillsboro
  - Forest Grove
- 1 temperature mitigation wetland
  - Fernhill NTS
- Stringent effluent phosphorus limit for almost 30 years
- Year-round ammonia removal
- Clean water, reuse water, biosolids, biogas, fertilizer

What is an Intelligent Water System?

- The best explanation I've found comes from the WEF/WRF/LIFT Intelligent Water Systems Challenge:

These systems… **"focus on leveraging data using the best available tools to help utilities better understand the dynamics of complex systems and make better decisions."**

- Leverage Data – Most data is underutilized, don't jump to adding infrastructure
- Best Available Tools – WIMS, SCADA, Excel, Power BI
- Complex System Dynamics – Daylighting relationships
- Better Decisions – Smarter actions, better recoveries, lower capital and operational cost

What is the goal of an Intelligent Water System?

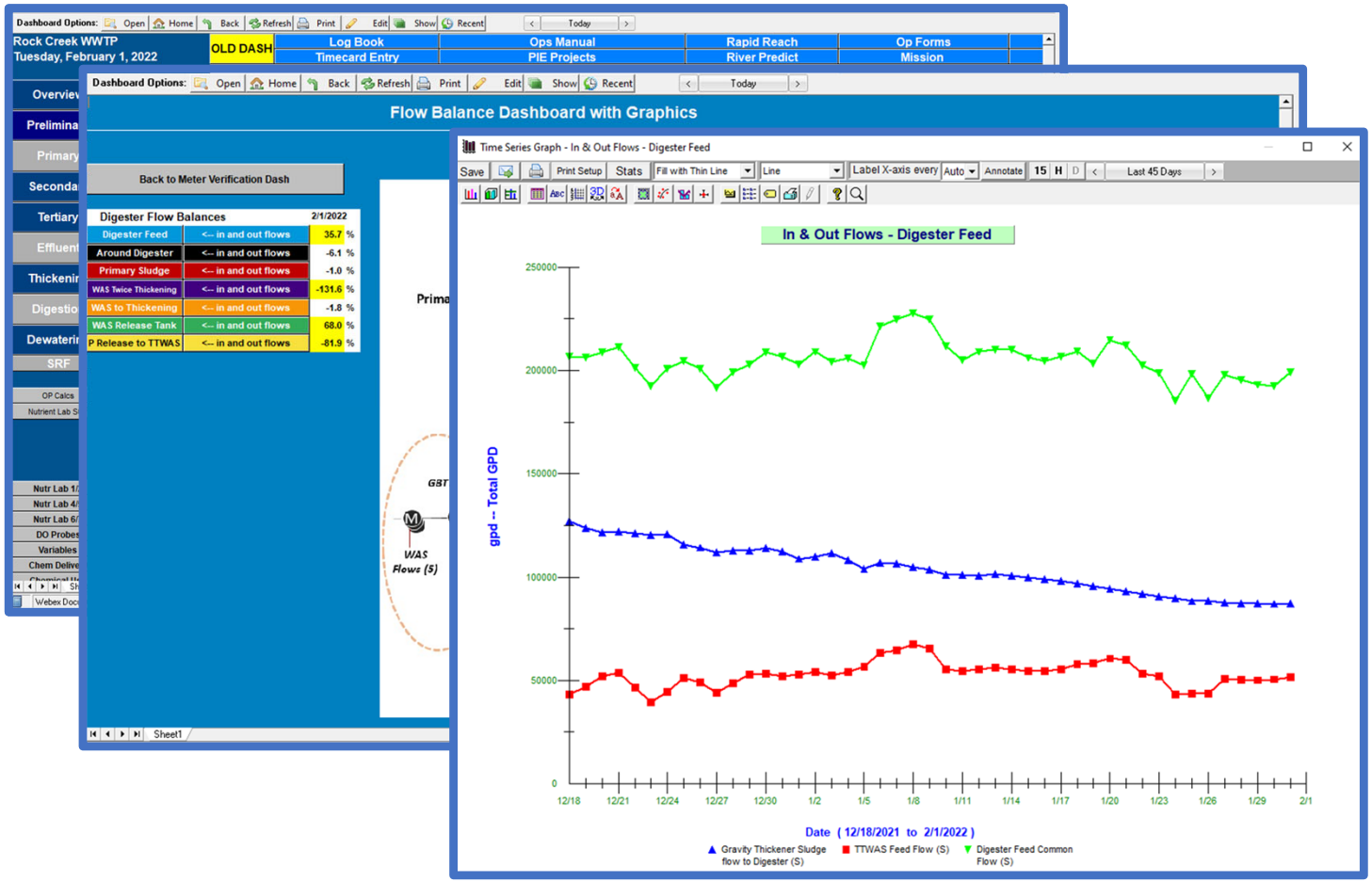
- Data→Information→Knowledge→Action (DIKA)
- Data is Useless
- Information is Interesting
- Knowledge is Power
- Action is Responsibility

Flow Balance Dashboards

- Using Data Better to get Better Data
- Accurate flow monitoring matters to:
  - Operations
    - Preventing digester overflows
  - Regulatory
    - Detention times for 503 regs
  - Planning
    - Quality model inputs = quality model outputs

Skylar Watnick
Operations Specialist - Research

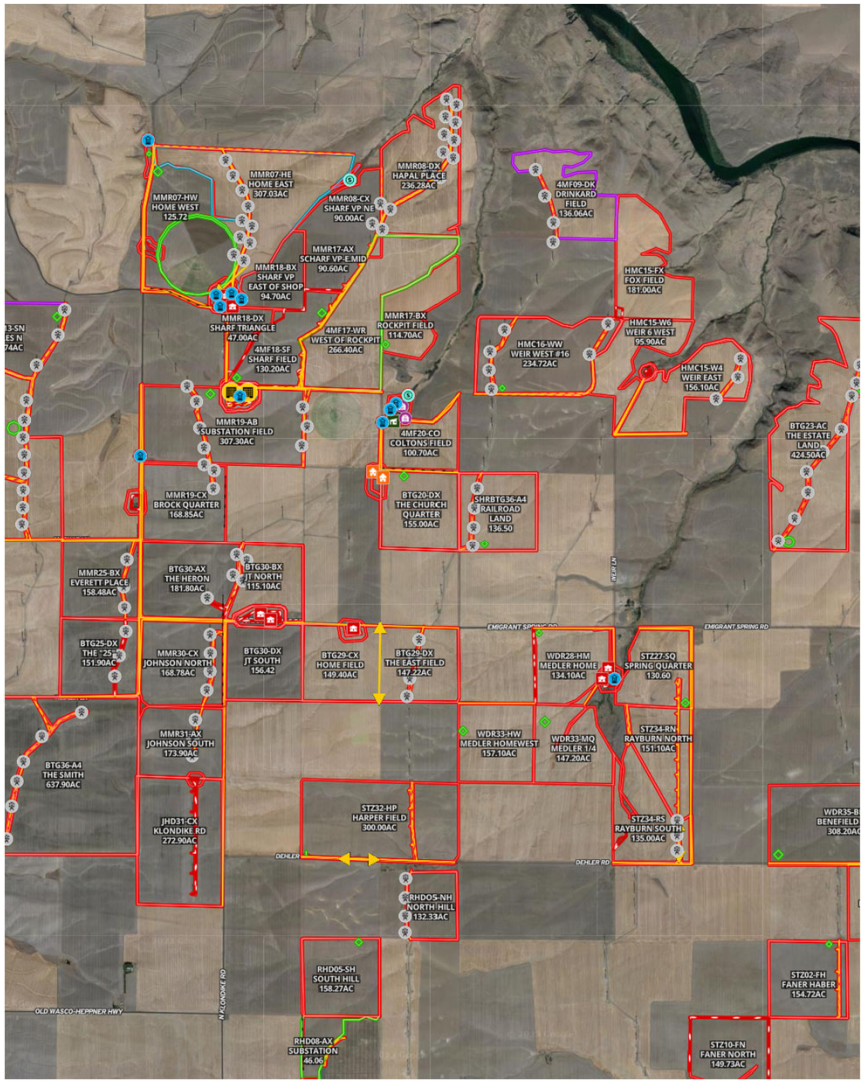
DIKA



- Data – Flows
- Information – Flow Balance Closure outside of +/- 10%
- Knowledge – The Gravity Thickener Sludge Flow Meter is Drifting
- Action – Work Order: “Please go clean the GT Sludge Meter”

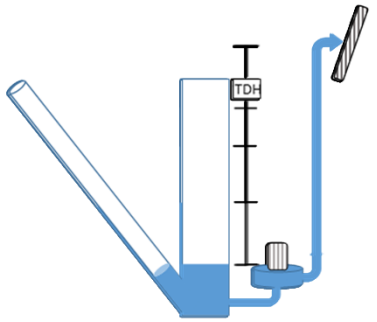
Data Visualizations

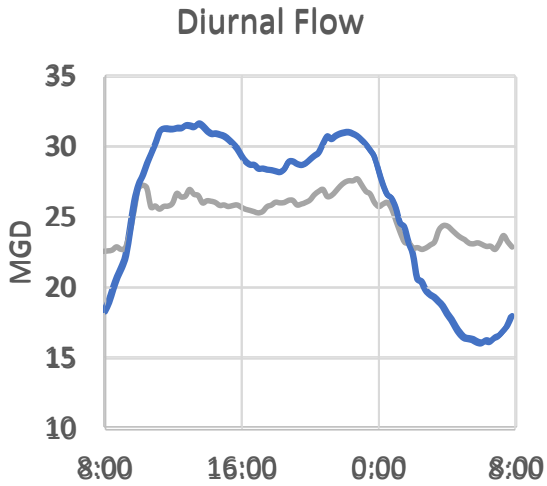
- Can you achieve DIKA simply through better data visualizations?
- Yes…but I suppose it only assists Human Intelligence.
- Be sure of your knowledge before taking action.



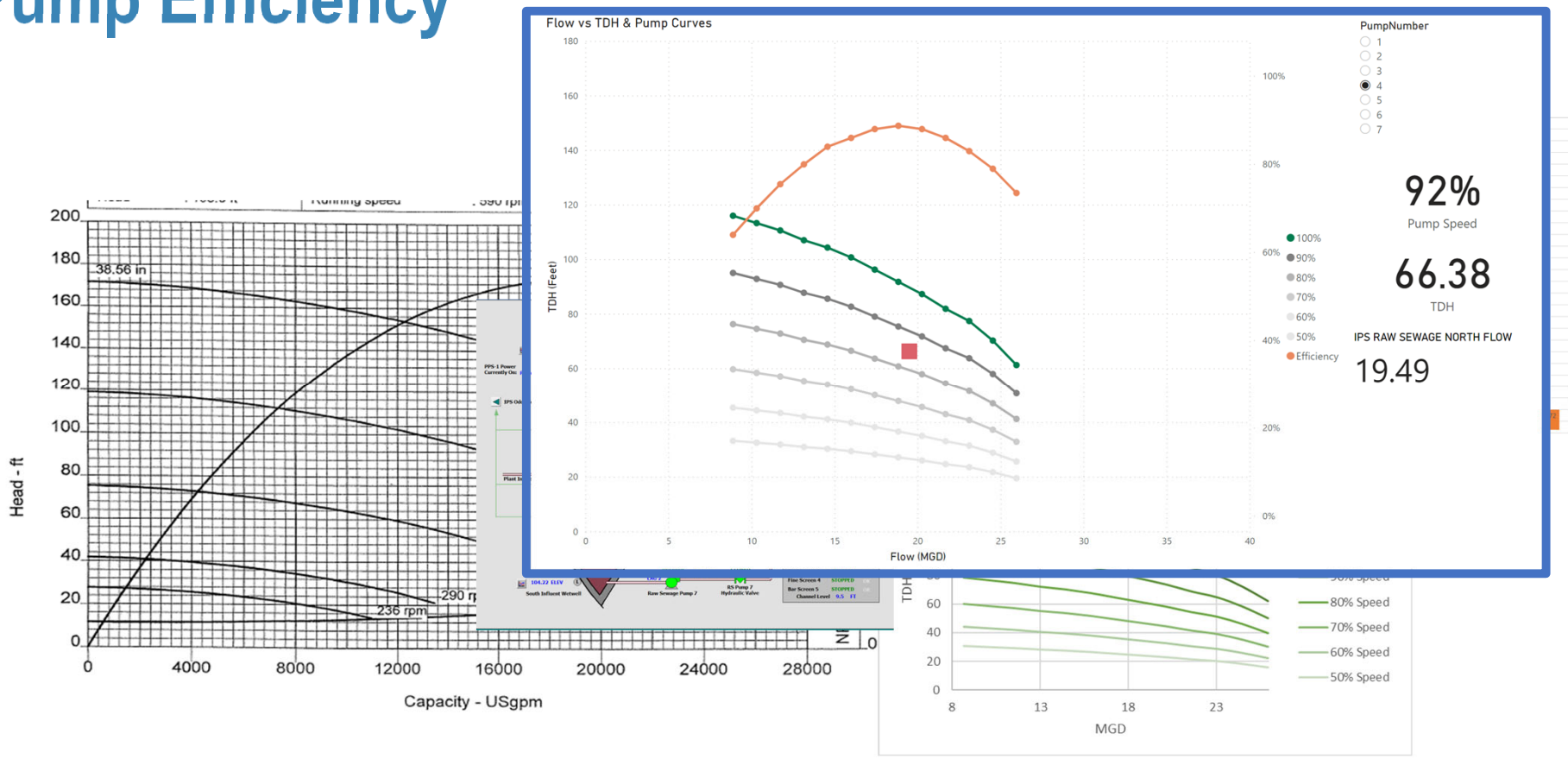
Intelligent Influent Flow Management

- Catalyzed by the inaugural WEF/WRF/LIFT Intelligent Water Systems Challenge in 2018
  - Simple effort to raise the level in the IPS, reduce TDH, gain energy efficiency
- Continued in the 2021 Challenge to FEQ
  - Maximize the pumping efficiency of the IPS within plant and conveyance constraints
- To Flow Equalization and Beyond

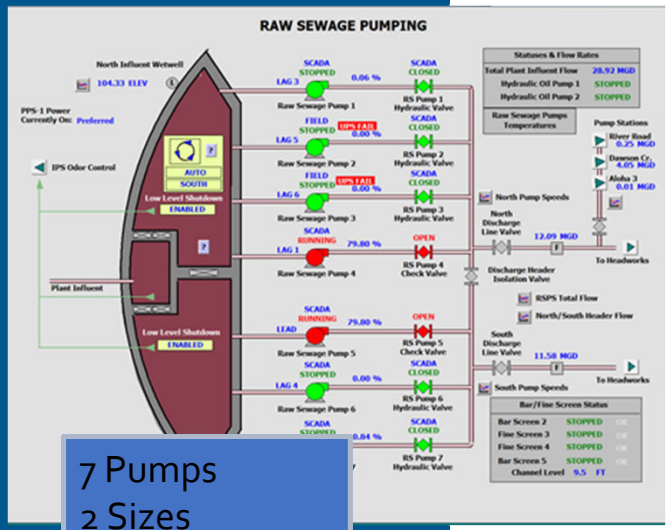




Pump Efficiency



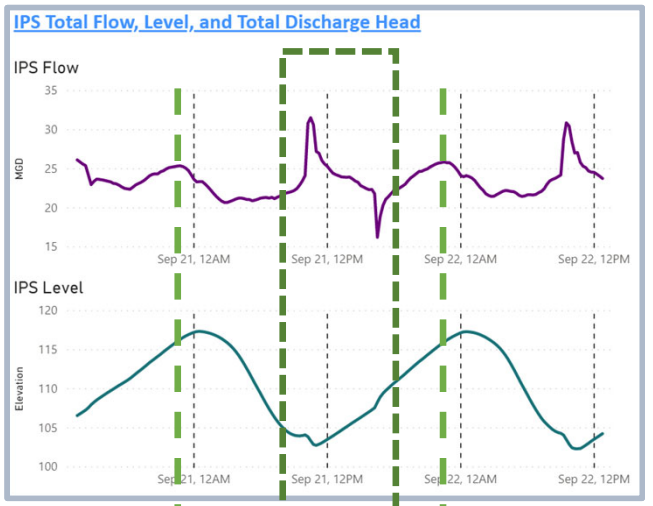
Power to Pump Efficiency

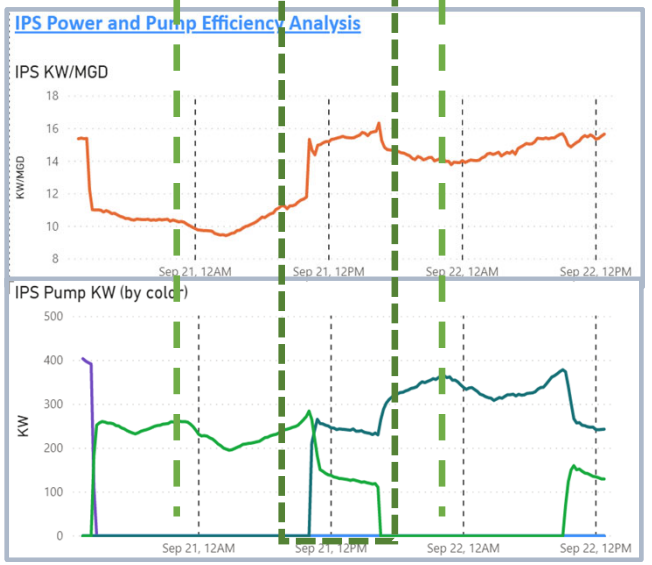


7 Pumps
2 Sizes
2 Headers
2 Flow Meters

Pump kW, Total IPS kW, Total IPS Flow

kW/MGD





Applications for Advanced Data Analytics

- Advanced Data Analytics
  - Machine Learning
  - Artificial Intelligence
  - Digital Twin
- Powerful tools with the potential for rapid optimization.
- **However**…the potential benefit is proportional to the current state of operational optimization.
- Guided by Human Intelligence

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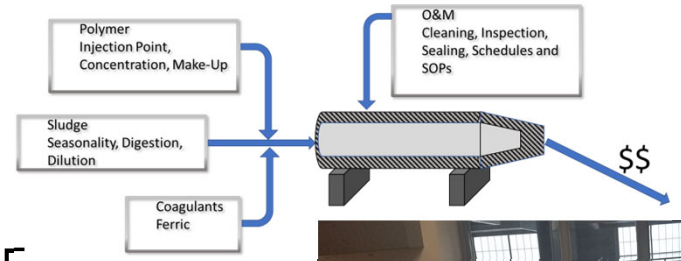
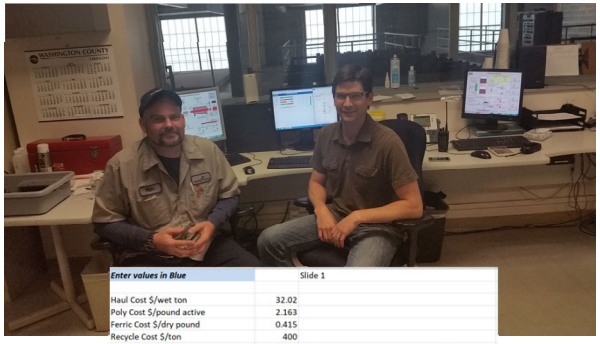
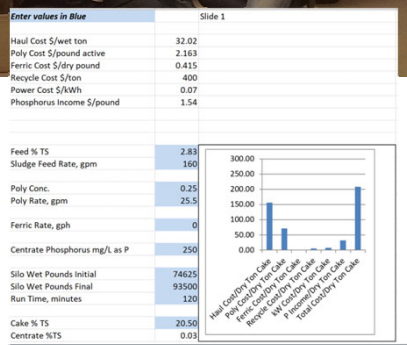
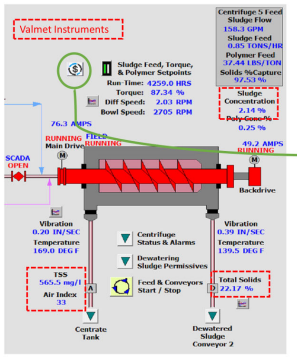
Dewatering Optimization

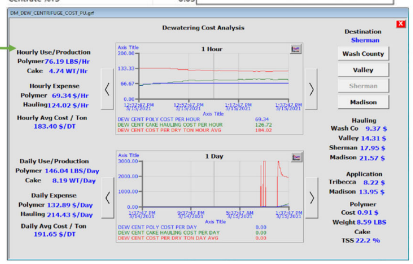


- Making biosolids is a huge cost center in WRRF.
  - Polymer, hauling, application, recycle
- Yet, process control based on daily lab analysis of cake and centrate quality, disregard for polymer dose.
- 2014 – Chris and Mike start to optimize to total cost.
- “Real-time” Excel Spreadsheet.
- On-line Instrumentation, Real “real-time” cost feedback in SCADA.
- Plus a dozen other ideas and experiments.



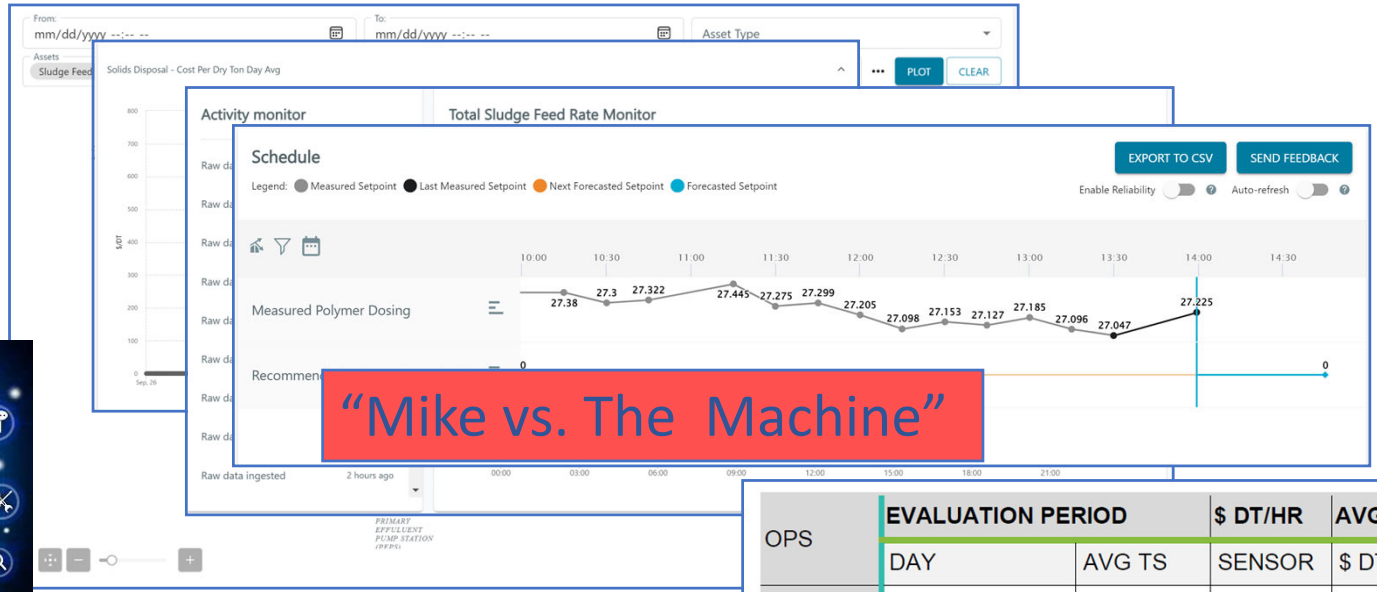






AI/ML

- ~ 135 SCADA Tags plus Lab Data
- 15 minute data
- 3 years historical
- 15 minute real time data transfer



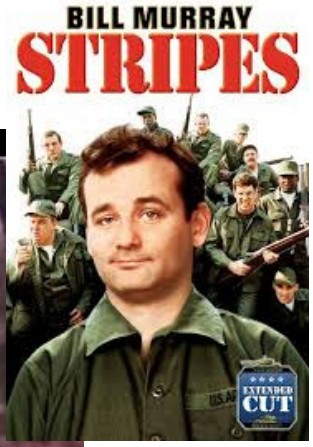
"Mike vs. The Machine"

- Mike and Chris, 5 years, from ~ 50% Optimized to >95% Optimized
- AI can get you there in a matter of months

	EVALUATION PERIOD		$ DT/HR	AVG
OPS	DAY	AVG TS	SENSOR	$ DT/HR
CWS	9/27/2021	2.84	$198.38	$198.38
	9/28/2021	2.79	$202.58	
	9/29/2021	2.80	$200.12	
AI	10/4/2021	2.78	$195.40	$195.40
	10/5/2021	2.76	$194.24	
	10/6/2021	2.76	$201.67	

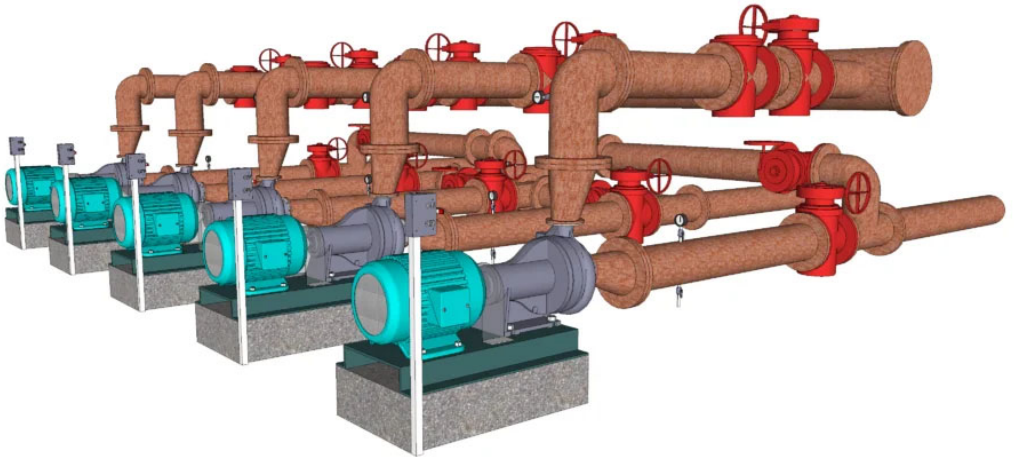
Obstacles

- Data Quality
- Data Security
- Data Re-integration
- Data Architecture



Data Quality

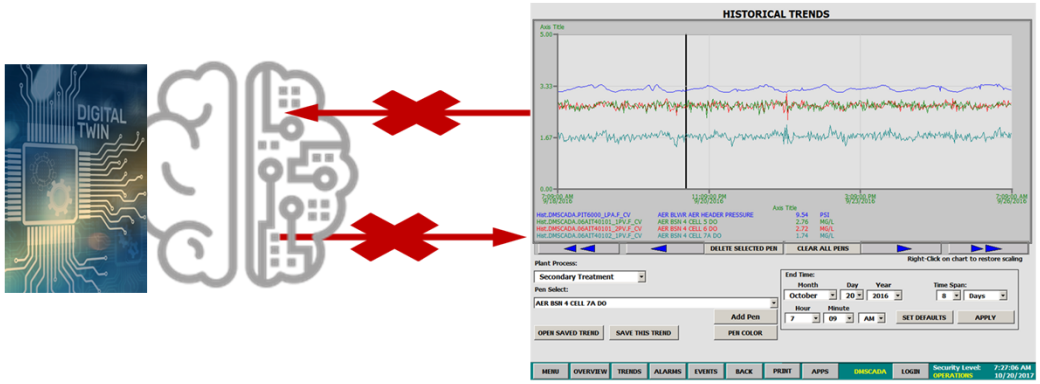
- Representative Sampling
- Conscientious Sampling
- Lab Analysis
- Instrument Validation and Calibration
- Control Charts
- Flags
- Statistical Data Quality Analysis
- Data Cleaning



https://embed-3dwarehouse-classic.sketchup.com/model/u06dc2ec7-33cc-46f6-b12c-5e6db68342a4/Return-Activated-Sludge-Pump-Train-Animated

Data Security

- Direct communication and integration of AI/ML platforms and facility data is prohibited. (And not functionally easy)
  - Cannot share a common database
- Requires packaging data into csv every fifteen minutes, leaving in a virtual bus station locker for AI/ML to pick up.
- Return of information through web interface (trends, forecast, advisor), but utility generally does not own the data behind it.

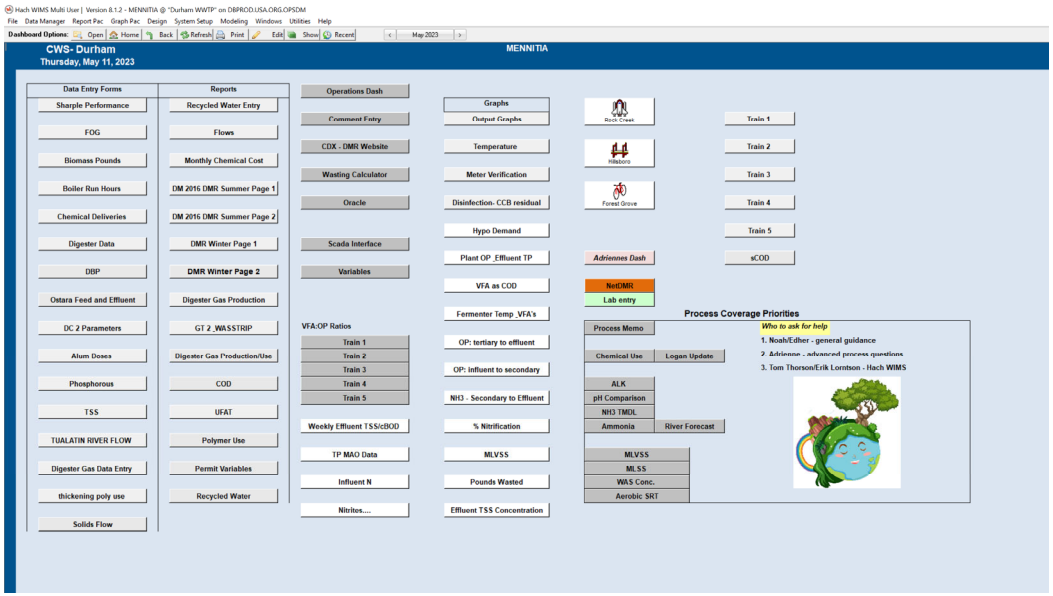


Data Re-integration

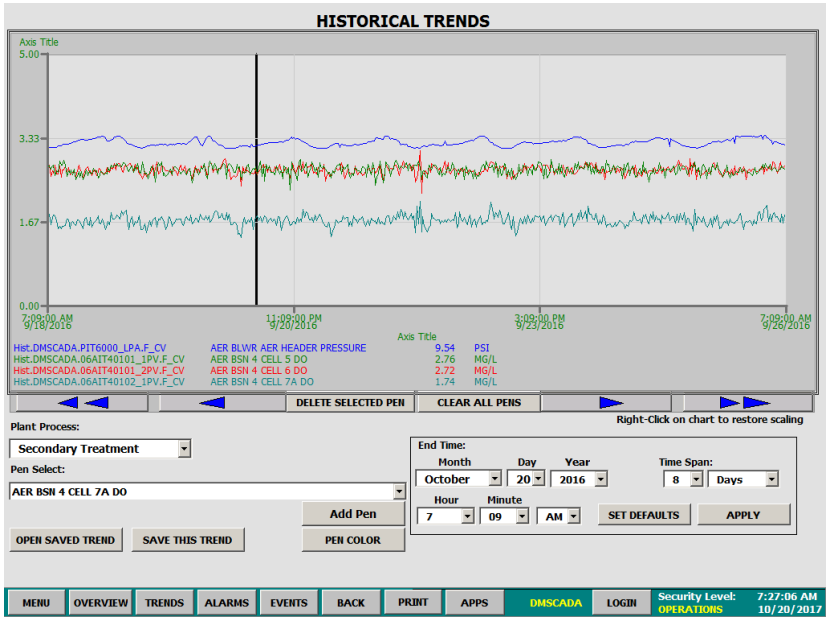
Culture

- Home base is WIMS and SCADA for daily plant operation
- Anything beyond those 2 programs must be VERY valuable to warrant daily viewing

HachWims



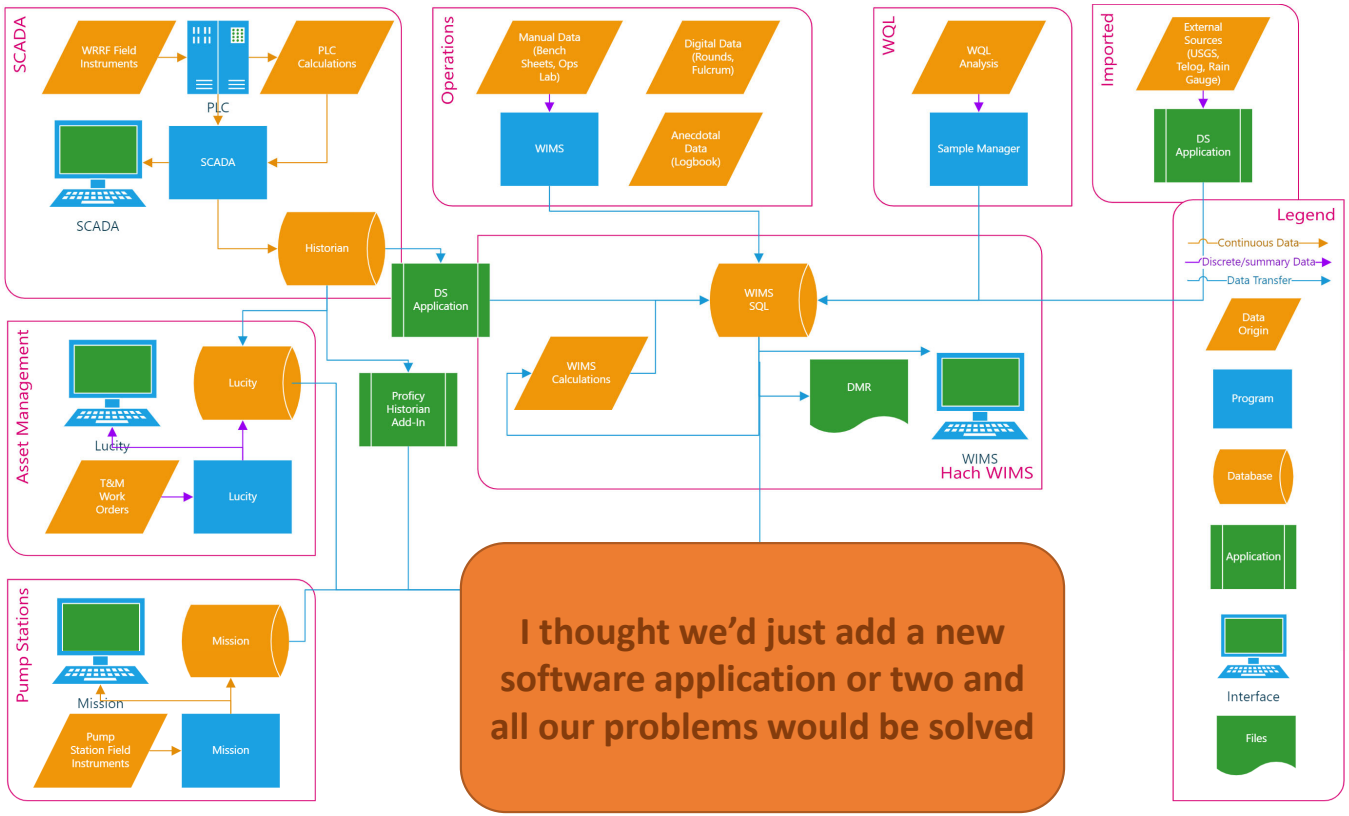
SCADA trends



Data Architecture

Software

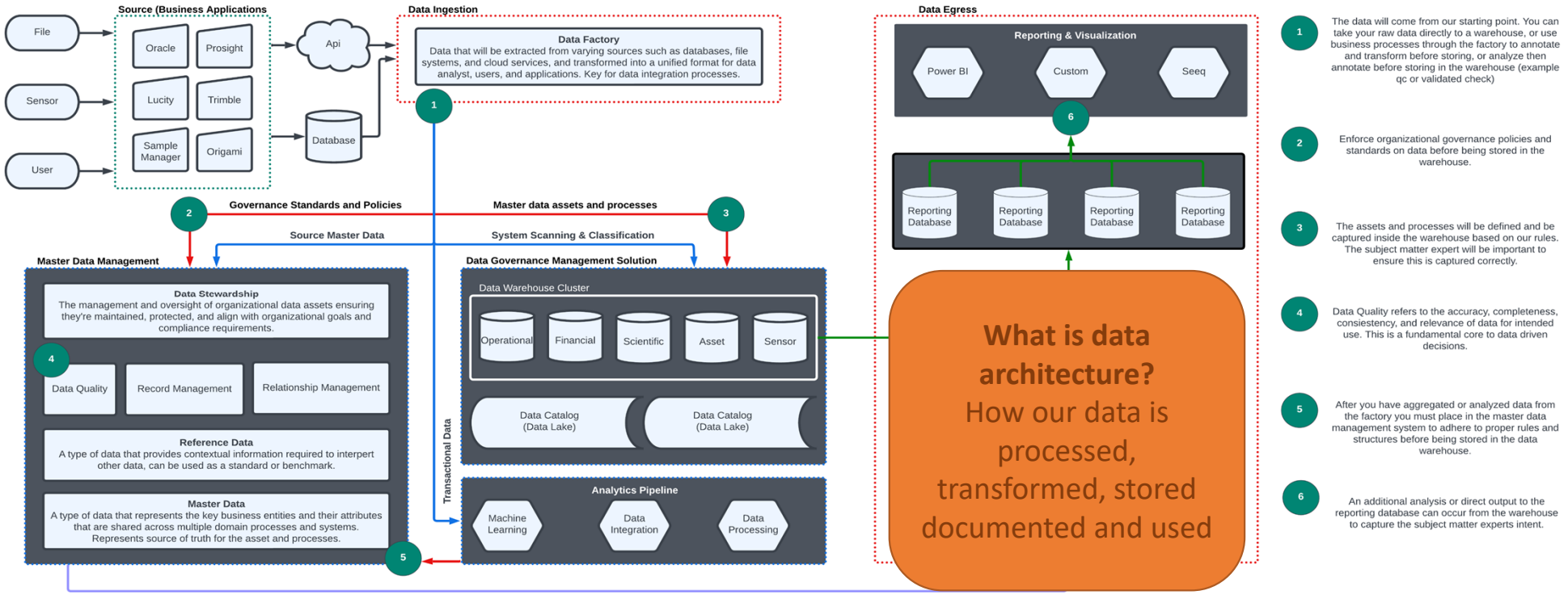
- Our software “home base” systems are limited in advanced functionality and can’t aggregate data well



Modernizing Data Architecture is Critical to Advancing Data Analytics

I learned that our current data architecture needs a major overhaul

Then we can layer on new software and better incorporate advanced digital tools



1. The data will come from our starting point. You can take your raw data directly to a warehouse, or use business processes through the factory to annotate and transform before storing, or analyze then annotate before storing in the warehouse (example qc or validated check)
2. Enforce organizational governance policies and standards on data before being stored in the warehouse.
3. The assets and processes will be defined and be captured inside the warehouse based on our rules. The subject matter expert will be important to ensure this is captured correctly.
4. Data Quality refers to the accuracy, completeness, consiestency, and relevance of data for intended use. This is a fundamental core to data driven decisions.
5. After you have aggregated or analyzed data from the factory you must place in the master data management system to adhere to proper rules and structures before being stored in the data warehouse.
6. An additional analysis or direct output to the reporting database can occur from the warehouse to capture the subject matter experts intent.

Digital Twin

Clean Water Services
Hybrid Optimizer
by Jacobs MAIA

THE Water Research FOUNDATION

ODIN

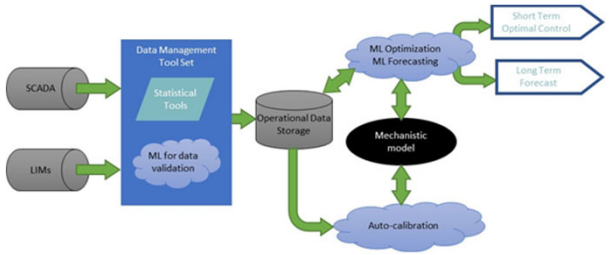
Operational **D**ecision-making **I**ntelligence for **N**utrient control

Timeline of digital twin development

- **2020**: Worked with MAIA Analytica on BPR forecasting through a National Science Foundation grant
- **2022**: WRF 5121 with Jacobs and MAIA Analytica. CWS pilot building on data infrastructure and lessons from previous work.
- **2023**: Digital twin just went into production. Still lots of tuning and dashboard development before its ready to show to operations.

Goals of the project

- Predict today's daily average plant influent orthophosphate (OP) load
  - This is actually a 24-hour forecast
- Recommend an alum dosing setpoint to maintain a requested primary effluent OP load

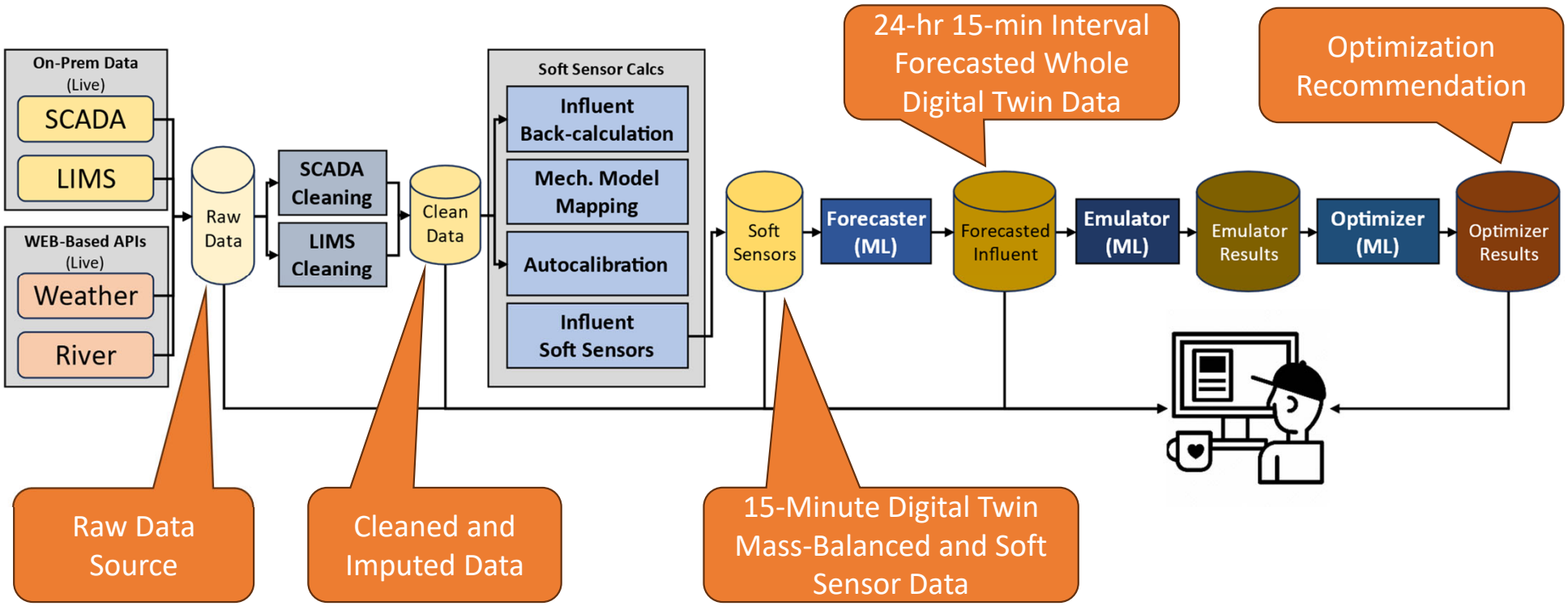


Why a digital twin when an analyzer will do?

- Opportunity to demonstrate added value
  - Flow, ammonia, soluble COD
    - ❖ Soft sensor and 24-hour forecasts
  - Automated data quality checks → shorter discovery time of erroneous data
  - Modularity for expansion (from other ODIN pilots)

ODIN Overall Workflow Structure

- Each step produces additional useful information



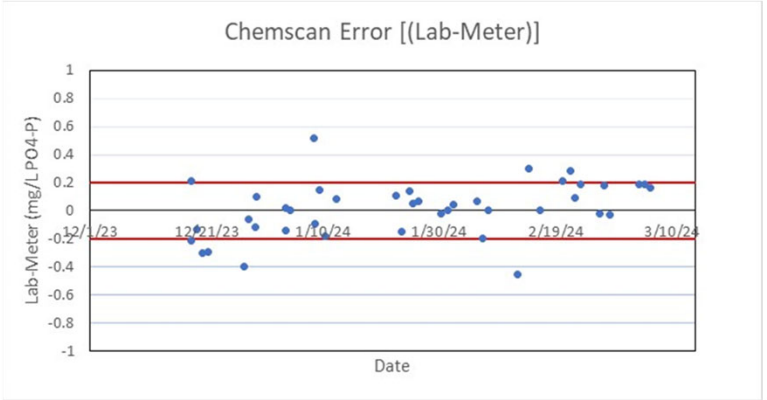
Data

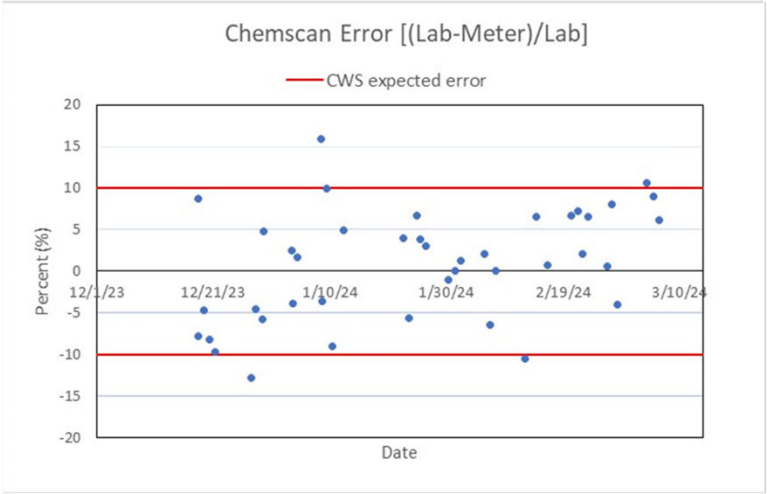
- ~70 SCADA variables exported
  - Plant flows (influent , primary effluent, plant recycles, WAS/RAS)
  - Air flow rates, DOs
  - SE nutrients, mixed liquor TSS values
  - Alum dosing information
- ~140 LIMS variables
  - Influent, primary effluent carbon and nutrient characterization
    - We measure a lot more “model” fractionations than most utilities
  - Plant recycle characterizations
  - Mixed liquor TSS
  - …….
- Weather information, river flow

- Our data is transferred externally only
- We get information back through a web interface
  - Haven’t crossed the cyber-security hurdle yet
- This is not sustainable long term because we don’t have access to most of the wealth of information stored in the digital twin system

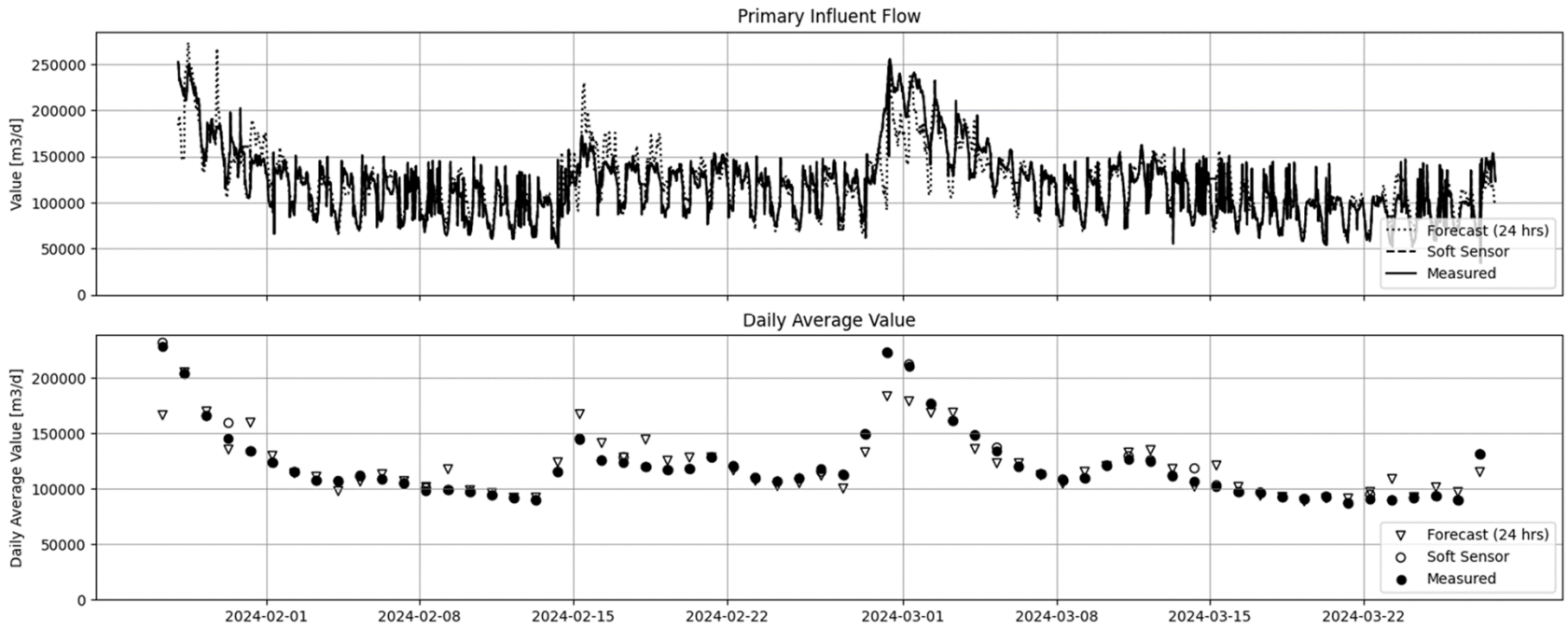
Performance Metrics

- Digital twin performance metrics
- Orthophosphate, ammonia load/concentration forecasts
  - +/- 20%
- Flow forecasts
  - +/- 5%

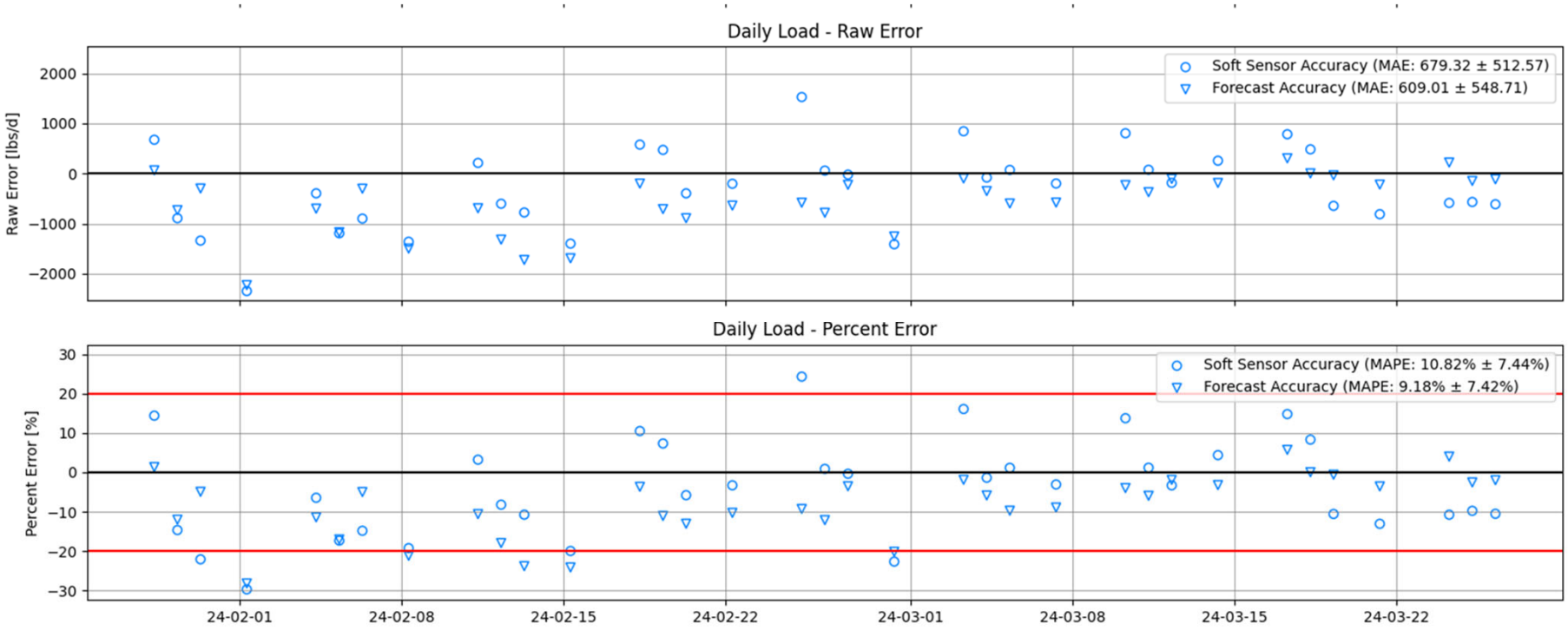




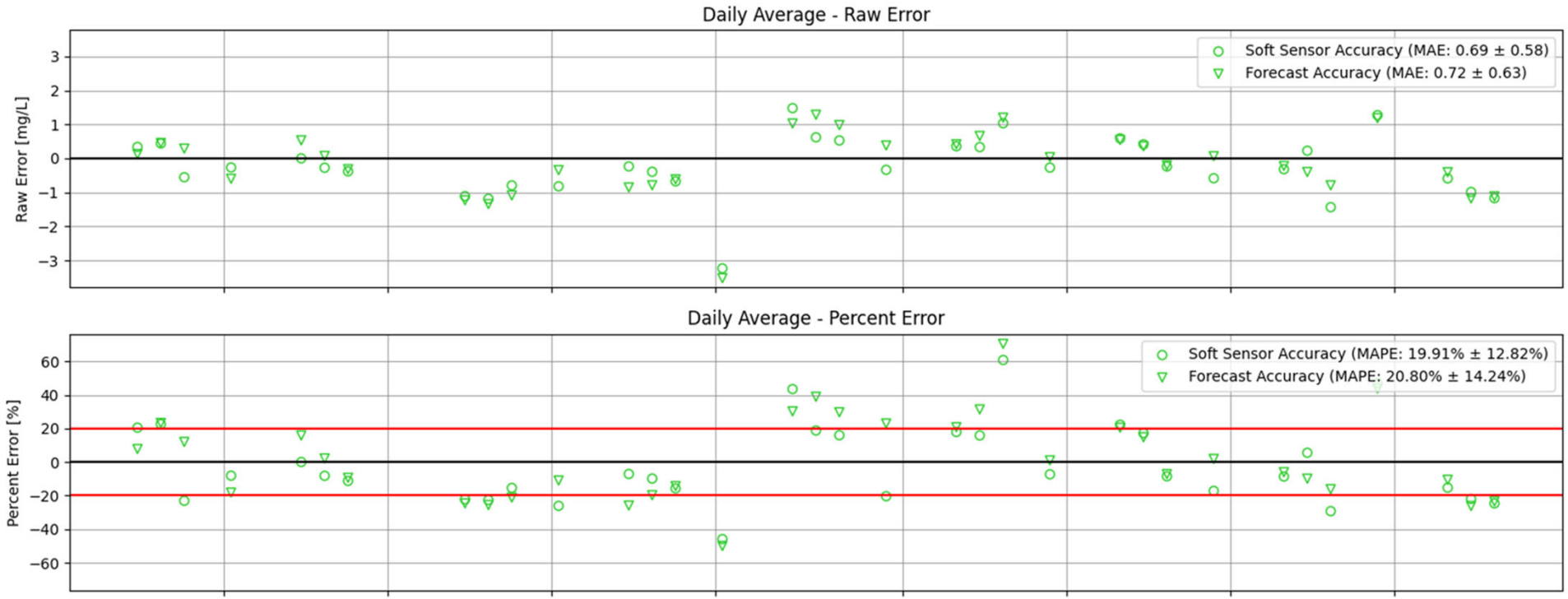
Flow Prediction



Ammonia Loading



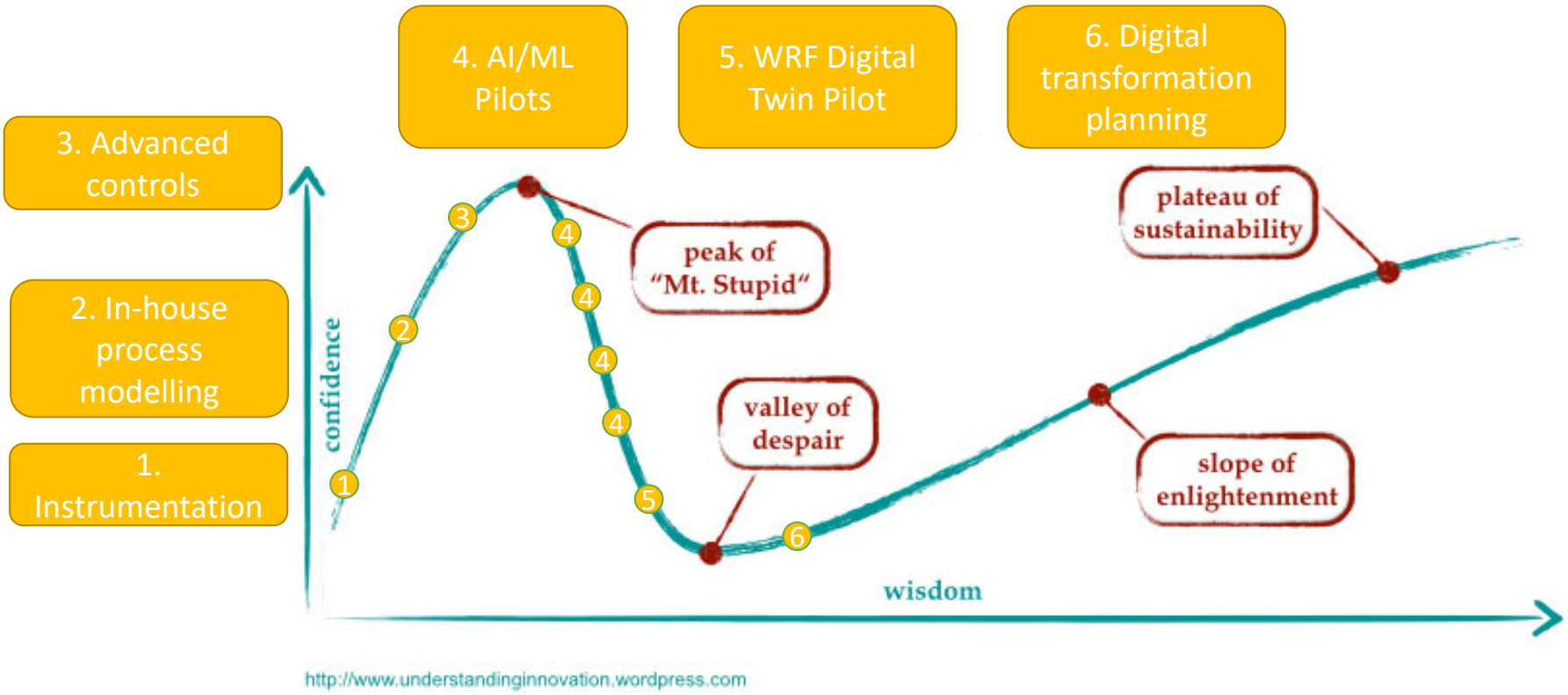
Phosphorus Concentration



Closing thought

A Pop Psychology Tour of Our Digital Water Journey

Uncovering our ignorance and learning how to do things better



Thank you, discussion…

Adrienne Menitti, Peter Schauer, Mike Gates, Skylar Watnick, Jeff Van Note, Greg Arrigotti, Brandon Wick, Kyle Heffron, Leila Barker, Ornella Sosa-Hernandez, Justine Abrook, Erik Lorntson, Kyrie Hale, Leslie Raymond…

Chris Maher | Senior Operations Analyst
Clean Water Services | Technology Development and Research
3235 SE River Rd | Hillsboro OR 97123
o 503.547.8037| **m** 970.389.6985
email: maherc@cleanwaterservices.org
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