Unpacking the “Black Box”: Understanding and Using Advanced Data Analytics to Optimize Operations

Thursday July 23, 2020  
1:00 – 3:00 PM ET
How to Participate Today

- Audio Modes
  - Listen using Mic & Speakers
  - Or, select “Use Telephone” and dial the conference (please remember long distance phone charges apply).

- Submit your questions using the Questions pane.

- A recording will be available for replay shortly after this webcast.

Today’s Presenters

- Mark Harris, Town of Hillsborough, Ca. (Moderator)
- Dr. Andrew Shaw, Black & Veatch
  - Advanced Data Analytics
- Richard Loeffler IV, EmNet
  - Case Study: Real Time Decision Support Systems (RT-DSS)
- Ryan Sanford, P.E., DHI
  - Digital Twin Solution & Case Study
- Andy Crawford, Woodard & Curran
  - Operator Rounds: Real Time Analytics To Give Perspective
Advanced Data Analytics
Introduction
Outline

- Get M.A.D.
- Data Integration
- Digital Twins

Get M.A.D.
The important thing about measuring is to give you feedback.
The important thing about analysis is to make sure you understand deeply. Without it you are roaming in the dark. Without it you decide poor things. To many it seems difficult. When you succeed in solving the puzzle it is a great sentiment.

The important thing about decisions is that you make them before you must. To lead is to make right-minded decisions. To react is to wait until only one option is available. Your largest obligation is to make good decisions that are serving the common good.
DATA INTEGRATION

DIFFERENT TIMESCALES FOR DECISIONS

<table>
<thead>
<tr>
<th>Time Scale</th>
<th>Level</th>
<th>Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years/decades</td>
<td>Strategic level</td>
<td>Strategic decision making</td>
</tr>
<tr>
<td>Hours/weeks</td>
<td>Plant-wide control level</td>
<td>Operational decision making</td>
</tr>
<tr>
<td>Minutes/hours</td>
<td>Unit control level</td>
<td>Automatic or manual control</td>
</tr>
<tr>
<td>Seconds/minutes</td>
<td>Control loop level</td>
<td>Automatic control</td>
</tr>
</tbody>
</table>
ANALYTICAL TOOLS

Single signal analysis
- Filtering
- Outlier detection
- Repairing datasets
- Statistical process control

Mathematical models
- Linear regression
- Multivariate regression
- Diagnosis
- Simple dynamic models
- Hydraulic models
- Biological reaction models

Performance indicators
- KPI
- Benchmarking

BUILDING AN INTEGRATED APPROACH

- Leverage same assets across more than one application, especially for:
  - Connectivity
  - Analytics

- Data layer and analytics capabilities aggregated in center of solutions
**BRAINSTORMING DATA SILOS**

**MONITORING & DIAGNOSTIC CENTER**

- Gathers, filters and analyzes plant data
- Identifies emerging issues
- Quantifies the cost and risk
- Makes recommendations for corrective action
**Digital Twins in the Water Sector**

“A Digital Twin can be defined as an integrated accurate digital representation of our physical assets, systems and treatment processes. It will unlock value by enabling improved insights that support better decisions, leading to better outcomes in the physical world.”
User based decision support via a digital twin

- **Site Manager**: "I need to run the site to cost."
- **Operator**: "I need to conduct maintenance and be ready to respond."
- **Optimiser**: "I need to monitor operations of the site."
- **Modeller**: "I need to understand the repercussions of planned and unplanned work."
- **Asset Planner**: "I need to get the most value from investments."
- **Designer**: "I need analyse and design the optimal water assets."

**Analysis of Use Cases Across the Asset Lifecycle**

- **Design**: Different design approaches can be tested and the operating performance of the asset assessed against success criteria.
- **Build**: Project BIM models can be tested against existing assets for integration and modular construction phased to optimize uptime.
- **Commission**: Virtual commissioning can be undertaken using the twin.
- **Optimise**: Operational optimisation can be carried out at asset or system level. Predictive analytics can enable proactive changes to avoid incidents and lower costs.
- **Pro-actively Maintain**: Dynamic understanding of asset criticality, reliability and consequence of failure allows for agile proactive maintenance planning, lowering maintenance costs and avoiding asset failures.
- **De-commission**: Activities can be tested on the twin to ensure end of life process is managed and risks are mitigated.
- **Recycle/Repurpose**: Data can be repurposed for secondary use. Asset component reuse can be tested to ensure it is fit for purpose.

**CREATE** | **OPERATE** | **MAINTAIN** | **DISPOSE**
Case Study:
Real Time Decision Support Systems (RT-DSS)
What’s RT-DSS

Computer-based information system that assists in decision-making activities in real time.

- process collection system and watershed data,
- approximate the impact of rainfall,
- evaluate and optimize operational strategies

Combined, these can provide real-time operational recommendations to operators.
What’s RT-DSS

- Data Model
- GUI
- Human
- Ultimate Decision Maker
- Self Learning Hydraulic Model
- Level and Flow Rainfall WQ

Data becomes Information
“Glass Box” Implementation

- Co-design and Collaboration
- Open Modular Architecture
- Sensor/Model Agnostic
- Operations focus
- Leverages Investments
- Real Time Decision Support Framework
Turn on the Lights!™

Data + Model Integration

- Measured Data
- CHRS Data

Rain → Neural Network → Flow

Time of Day
Data + Model Integration = Predictions

Measured Upstream Flow
Forecasted Upstream Flow

Recommend + Act

MEASURED RAINFALL: 0.91 in
EXPECTED TOTAL RAINFALL: 1.45 in (10 hours)

ESTIMATED TIME UNTIL WET WEATHER MODE 8.75 HRS

RECOMMENDATION: DRY WEATHER

CURRENT AVORS FLOW DOWNSTREAM 38.0 MGD
Applications:

- Enhance information re: what’s happening in the collection system
- Reduce sewer overflows (wet & dry weather)
- Maximize storage and conveyance in collection system
- Predict peak WWTP flow timing to balance out diurnal flows
- Provide operational decision recommendations

Coordinated Decision Support
Coordinated Decision Support

Outcomes – South Bend, IN

More rain, fewer overflows – $500M less cost
Automated Systemwide Storage

Selected 16 inline storage facility sites based on volume of sewer, impact on overflow reduction, constructability, and LEAF as possible.

All sites communicate via SCADA and DCS system.

~$145M in capital project savings.
Enhance Data Use + Optimize WWTPs

- Eliminate SSOs, manage peak flows across 3 main WWTPs
  - Leverage data from 700+ installed sensors and meters
  - Minimize time plants operate near peak capacity (adapt to seasons, capacity)
  - Reduce/eliminate major CIP projects
  - I/I reduction
  - Load balancing for indirect potable reuse system implementation

Wet Weather Storage Activation

- Full model+data engine
- Runs 100 sims every 15 minutes
- Current conditions +/- 12 hours
- Probabilistic estimate of future flows
- Comprehensive situational awareness
- Provides high-level recommendations

Outcomes:
- Increased continuity of operations
- Operational knowledge aggregator
- Training tool for new recruits
- Forensic analysis
Summary

• RT-DSS represents an open, extensible framework that uses existing utility assets and information to put more data in front of operators and decision makers.
• Co-design ensures operations provides critical feedback necessary for to develop the most impactful tools.
• Enhanced collection system knowledge can have watershed scale impacts for collections and treatment assets.
• Involving all stakeholders in RT-DSS development ensures the entire team designs the system, and identifies/mitigates all possible challenges and needs.

Thanks for your time!!

Richard Loeffler
richard.loeffler@xyleminc.com

Beth Goldstein, PE
bgoldstein@hydroce.com
We’re on a quest
to help solve the world’s toughest challenges in water
environments

DHI Digital Twin Solution

1. What is DHI’s Digital Twin?
2. Case Study – Viby WWTP
   - Problem
   - Methodology
   - Solution
   - Solution in action
   - Results
3. Enabled by Data Analytics
Digital Twin

Three Dimensional Interactions:

1) Company performance models
2) Asset database(s)
3) Model simulations physical systems
Digital Twin
Integration of Cyber and Physical System

WWTP Capacity Expansion for under $2M
Advanced Modelling, Real-time Control, and Densified Activated Sludge
Viby WWTP
case study
**Viby WWTP – The Problem**
90,000 PE to 120,000 PE

- Influent load is rapidly increasing by 33%
- WWTP to be consolidated in 10yrs
- Tight nitrogen & phosphorus limits

*Aarhus Water: “Can the short-term capacity expansion be done for $2M?”*

*We think it might be possible.*
Project Approach

WEST Modeling
Sidestream Hydrolysis (Bio-P) vs. Extra N/dN Volume (Chem-P)

The solution

Maximize Oxic Volume
The solution

- Increase Aeration Capacity
- Maximize Oxic Volume

The solution

- Process Air Blowers
- Increase Aeration Capacity
- Maximize Oxic Volume
The solution

Diffuser Grid Upgrades
Process Air Blowers
Increase Aeration Capacity
Maximize Oxic Volume

The solution

Diffuser Grid Upgrades
Process Air Blowers
Increase Aeration Capacity
Maximize Oxic Volume
Maximize Denitrification Rates
The solution

Diffuser Grid Upgrades  Process Air Blowers
Increase Aeration Capacity
Maximize Oxic Volume
Maximize Denitrification Rates

Diffuser Grid Upgrades  Process Air Blowers  Load-based Control Selector  RAS-Control
Increase Aeration Capacity  Advanced N/dN Control
Maximize Oxic Volume  Maximize Denitrification Rates
The solution

External Carbon Dose-Control
NO3-Control  NH4-Control

Diffuser Grid Upgrades  Process Air Blowers

Load-based Control Selector
RAS-Control

Increase Aeration Capacity  Advanced N/dN Control

Maximize Oxic Volume  Maximize Denitrification Rates

The solution

External Carbon Dose-Control
NO3-Control  NH4-Control

Diffuser Grid Upgrades  Process Air Blowers

Load-based Control Selector
RAS-Control

Increase Aeration Capacity  Advanced N/dN Control  Increase Clarifier Capacity

Maximize Oxic Volume  Maximize Denitrification Rates
The solution

External Carbon Dose-Control
NO3-Control NH4-Control
Diffuser Grid Upgrades Process Air Blowers Load-based Control Selector RAS-Control
Granular Activated Sludge Hydrocyclones
Increase Aeration Capacity Advanced N/dN Control Increase Clarifier Capacity
Maximize Oxic Volume Maximize Denitrification Rates

The solution

External Carbon Dose-Control
NO3-Control NH4-Control
Diffuser Grid Upgrades Process Air Blowers Load-based Control Selector RAS-Control
Granular Activated Sludge Hydrocyclones
SVI & Settling Velocity
Increase Aeration Capacity Advanced N/dN Control Increase Clarifier Capacity
Maximize Oxic Volume Maximize Denitrification Rates
The solution

- External Carbon Dose-Control
- NO3-Control
- NH4-Control
- SVI & Settling Velocity
- Granular Activated Sludge
- Hydrocyclones
- RAS-Control
- Load-based Control Selector
- Diffuser Grid Upgrades
- Process Air Blowers
- Increase Aeration Capacity
- Advanced N/dN Control
- Increase Clarifier Capacity
- Maximize Oxic Volume
- Maximize Denitrification Rates

Viby WWTP – original design
Viby WWTP – optimized design

External and internal NH₄ loads determine aeration in N/DN tanks
Results!

2019

(5.7 MGD)

2020

(30.8 MGD)

(13.7 MGD)

Nitrate Profile

2019

2020
Ammonium Profile

2019

2020

DIMS.CORE – Advanced Controllers

- Data assimilation
- Data Validation
- Automated reporting

Fosfor frigivelse

Høj belastning

NH₄⁺, NO₃⁻, PO₄³⁻
Thank you
Ryan Sanford, PE, Wastewater Process Engineer
rkes@dhigroup.com

Andy Crawford
Woodard & Curran

Asset Management Services Manager
• 10 years experience
• MS Env. Engineering
• Licensed Operator; NY, NJ
Operator Rounds: Real Time Analytics To Give Perspective
Andy Crawford
Woodard & Curran

Agenda

• Rounds – What is it REALLY?
• Rounds Design
• Data Collection Tools – Form Applications
• Leveraging Data – Do more with less
About Us

- Woodard & Curran is an integrated engineering, science, and operations company servicing public and private clients nationwide.

1,000+ PEOPLE

45 PLANTS

Rounds – What is it REALLY?

- Appearance, Color, Smell
- Measure
  - Trust but Verify
- Inspection
  - Maintenance
  - Process
Data Collection Tools – Form Applications

Key Ideas – Rounds/Form Design

- QA/QC
  - Expand
- Real-Time Analytics
- Embed Experience
- Follow up
- Integrate!
Collect Key Features
QA/QC Data Collection

- Structured Data Types
- Required Fields
- Min/Max Constraints
- Pick List / Radio Options

Explore/Transform
Real Time Analytics

- Historical Comparison
- Embedded Calculations
- Alert on bad entry
Learn / Optimize

- Conditional Questions
- Automated Follow Up

Learn/Review
Leverage Data – Do More with Less

- Digitize
- Integrations to:
  - BI Platforms
  - CMMS
  - GIS
  - Financial
  - Anything....
Our **people** are our best **decision-makers**.

Ultimately, we **trust them** to interpret data best.
DMR Dashboards

Wastewater Treatment Facility
DMR R-001 Page 2

Asset Management Data
Conclusion

- Advance Rounds Design
- Integrate Business Systems
- Leverage Data

Questions?