AQUAVISTA™ DIGITAL SERVICES

The Next Generation of Phased Activated Sludge Technology with Model Predictive Control

25th February 2020

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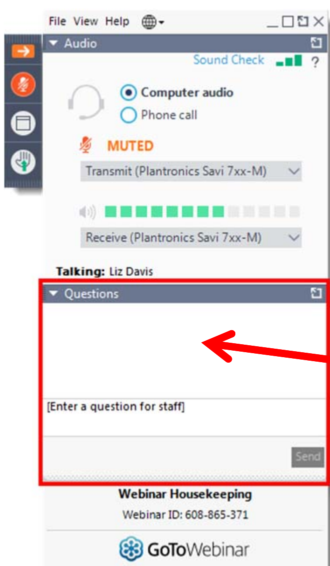
How to Participate Today



- **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.**

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Overview

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Agenda

1. What is Phased Activated Sludge Technology?
2. Characteristics of Phased Isolation Technology
3. Liberal, KS - Drivers and Solutions
4. Latest Generation of Phased Isolation Technology
5. What is AQUAVISTA Plant?
6. Question and Answer

Presenters

Mark Drake
VWT - Kruger
Product Manager

Pete Earles, PE
Earles Engineering
Principle

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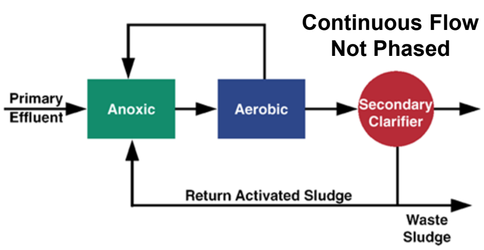
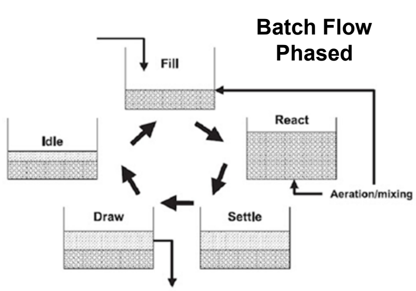
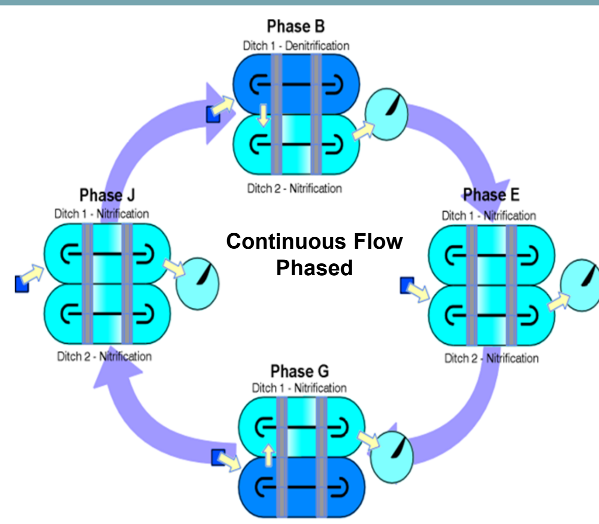
What is Phased Activated Sludge Technology?







Phased Isolation Ditch (PID) Technology
Known as BIO-DENITRO® 4

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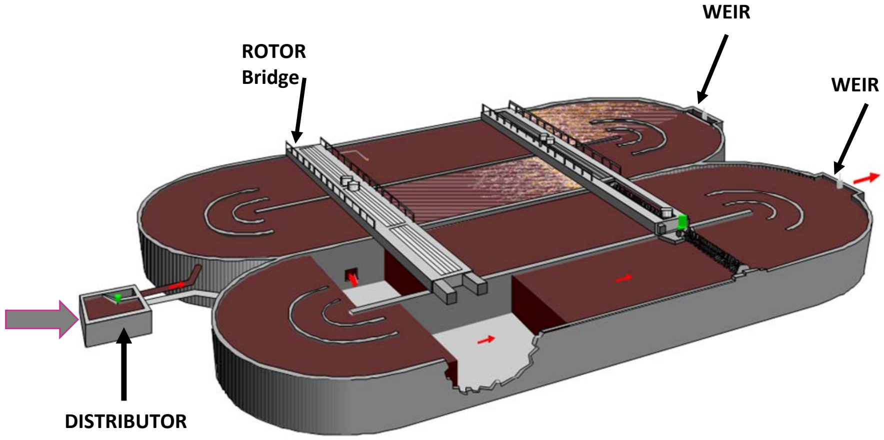
What is Phased Activated Sludge Technology?



Typical Arrangement for BIO-DENITRO® Phased Isolation Ditch System

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Characteristics of Phased Isolation Technology

- Phasing between Aerobic/Anoxic
- Phasing between Series/Parallel/Isolation
- Operate in Extended Aeration
  - HRT 18-24 hrs
  - SRT 12-20 days
- TN removal without recycle
- Conventional Clarifiers
- Time or Nutrient Monitoring Basis for Phase Transitions, via PLC

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Characteristics of Phased Isolation Technology

12 MGD Cary, NC BIO-DENIPHO Water Reclamation Facility

- BIO-DENIPHO® is a BIO-DENITRO® with Anaerobic Selectors Up Front
- Typical Design Effluent Values:
  - BOD <10 mg/L
  - TSS <10 mg/L
  - NH_3 <1 mg/L
  - TN < 5 mg/L
  - TP < 1 mg/L
- Secondary Anoxic Zones Used Based on Specific WW Make-up and Effluent TN Target
- Lower TP levels with Chemical Addition

The capital cost is relatively high at $2.84/gpd capacity as a new facility but compares well with others, which normally exceed $3/gpd. The O&M costs are estimated at $1.26/lb of TP removed and $0.41/lb of TN removed. These costs are remarkably low, reflecting the inherent advantages of this unique treatment process. The total costs were $2.21/lb of TP removed and $2.92/lb of TN removed.

Source: US EPA Municipal Nutrient Removal Technologies Reference Document - 2008

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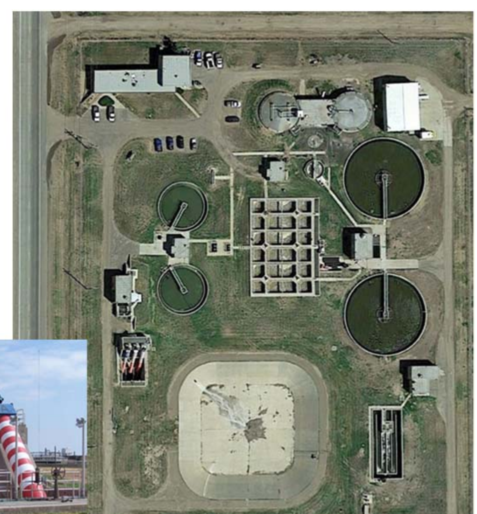
Liberal, KS - Drivers for a New Facility

- Existing Plant not too old (1985) but not in good shape
- City Plant Treating National Beef Waste
  - Combined TKN in = 120 mg/L
  - Combined TP in = 25 mg/L
- New NPDES limits for Cimmarron River on the way from KDHE
  - TKN effluent < 10 mg/L
  - TP < 1 mg/L
  - Time right to start thinking TN for future
- Difficult to find cost-effective combined plant solution
- Feasible for all National Beef to discharge via irrigation
- City moved forward to build new plant just for City wastewater on property just south of existing plant
- Key factors important to Liberal:
  - Compact Footprint
  - Process Responsibility / Guarantee
  - Advanced Controls / Advanced Service



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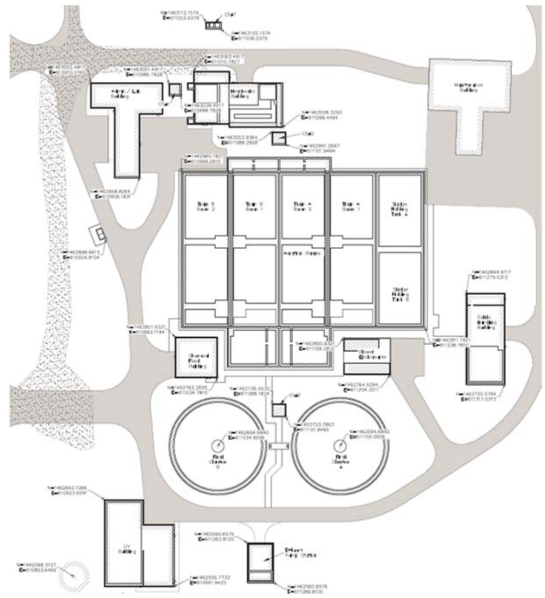

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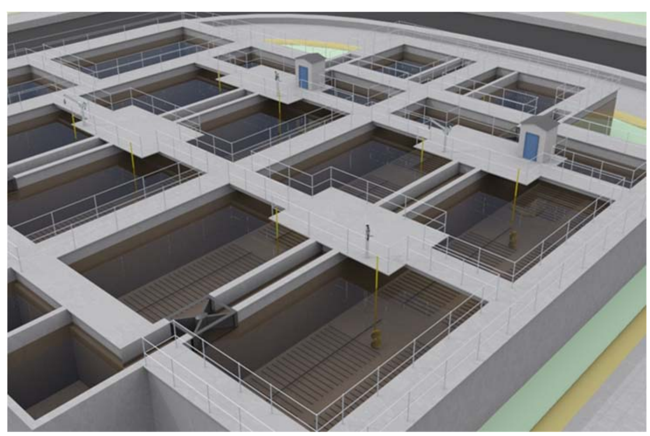
Latest Generation of BIO-DENITRO

- No Ditch, Go Deeper
  - Simplified/Cheaper Construction
  - Smaller Footprint
- Use Fine Bubble Diffusers
  - Lower Energy than Rotors
- Generally 20 - 30% Lower CAPEX and OPEX than rotor-based oxidation ditch PID System
- Liberal Influent:

Parameter	Value
Influent Flow, Average Design (MGD)	4.05
Influent Flow, Peak Day (MGD)	7.1
BOD_5 (mg/L)	250
TSS (mg/L)	250
TKN (mg/L)	70
TP (mg/L)	8
Elevation[3] (ft AMSL)	2,830
Min/Max Temperature (°C)	8/22

- Liberal Effluent:

Parameter	Value (Monthly Average)
$CBOD_5$ (mg/L)	< 30
TSS (mg/L)	< 5
TN (mg/L)	< 8[1]
TIN (mg/L)	< 5[1]
TP (mg/L)	< 0.5[2]



4.05 MGD BIO-DENIPHO Under Construction in Kansas

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Latest Generation of BIO-DENITRO

- Anaerobic Zones:

Parameter	Value
Number of Trains / Number of Tanks per Train	2 / 2
(Length/Width) per Tank (ft)	19 x 15
Side Water Depth (ft)	20.1
Total Anoxic Volume (MG)	0.17
HRT (hrs)	1.0

- BIO-DENITRO:

Parameter	Value
Number of Trains	2
Number of Phased Isolation Systems per Train	2
Internal Length per Ditch (ft)	151
Internal Width per Ditch (ft)	46
Average Side Water Depth (ft)	20
BIO-DENIPHO System Volume (MG)	4.16
Design Anoxic / Aerobic Operating Time (%)	34/66
System HRT (hrs)	24.6
System SRT (days)	18.9
MLSS at 8°C (mg/L)	4,000
System F/M Ratio (days^{-1})	0.08
Design Sludge Yield (lbs MLSS/lb BOD_5 applied)	0.85
Waste Activated Sludge (lb WAS/day), incl chem. sludge	7,000

- Secondary Anoxic:

Parameter	Value
Number of Trains / Number of Tanks per Train	2 / 1
(Length/Width) per Tank (ft)	36.2 x 38.0
Side Water Depth (ft)	20
Total Anoxic Volume (MG)	0.50
HRT (hrs)	3.0
Max Month Micro-C Estimate (gal/day)	≈ 240

4.05 MGD BIO-DENIPHO Under Construction in Kansas

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AQUAVISTA^{TM} Plant

Model Predictive Control

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WATER TECHNOLOGIES

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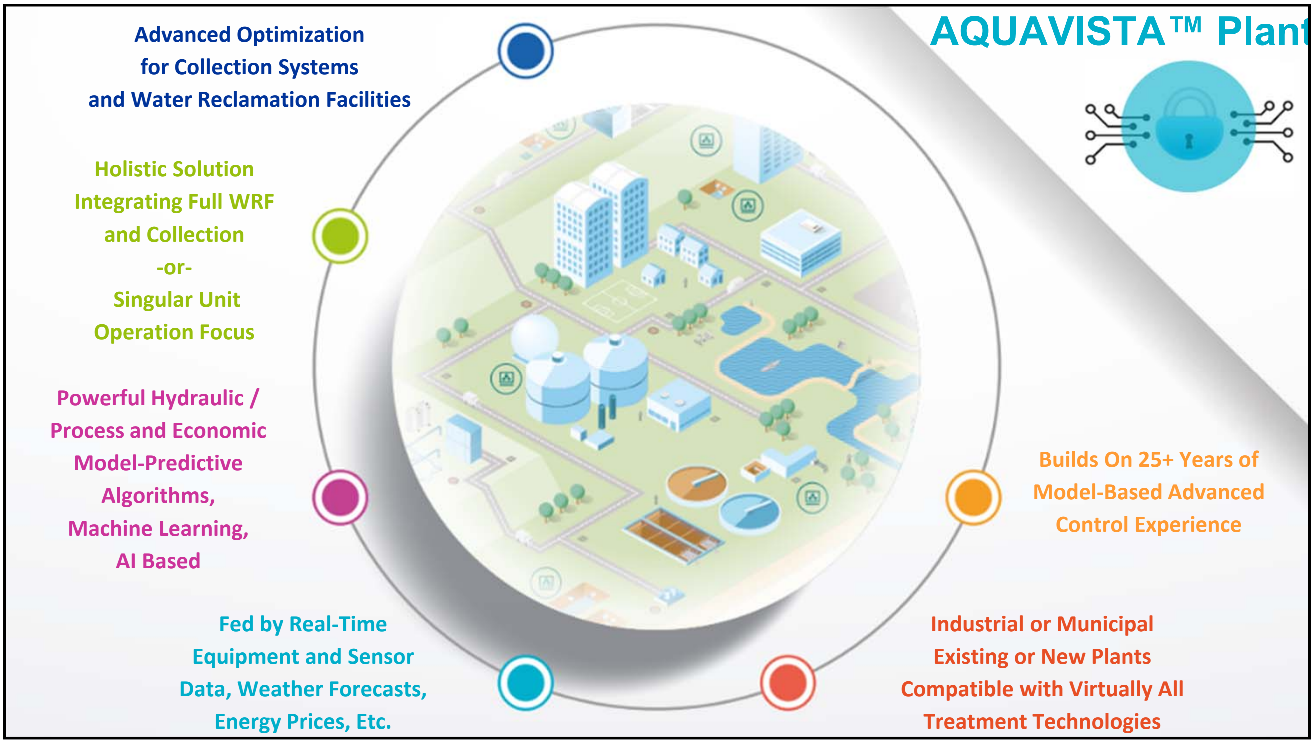
AQUAVISTA™ Plant
Advanced Optimization for Collection Systems and Water Reclamation Facilities
Holistic Solution Integrating Full WRF and Collection -or- Singular Unit Operation Focus
Powerful Hydraulic / Process and Economic Model-Predictive Algorithms, Machine Learning, AI Based
Fed by Real-Time Equipment and Sensor Data, Weather Forecasts, Energy Prices, Etc.
Industrial or Municipal Existing or New Plants Compatible with Virtually All Treatment Technologies
Builds On 25+ Years of Model-Based Advanced Control Experience

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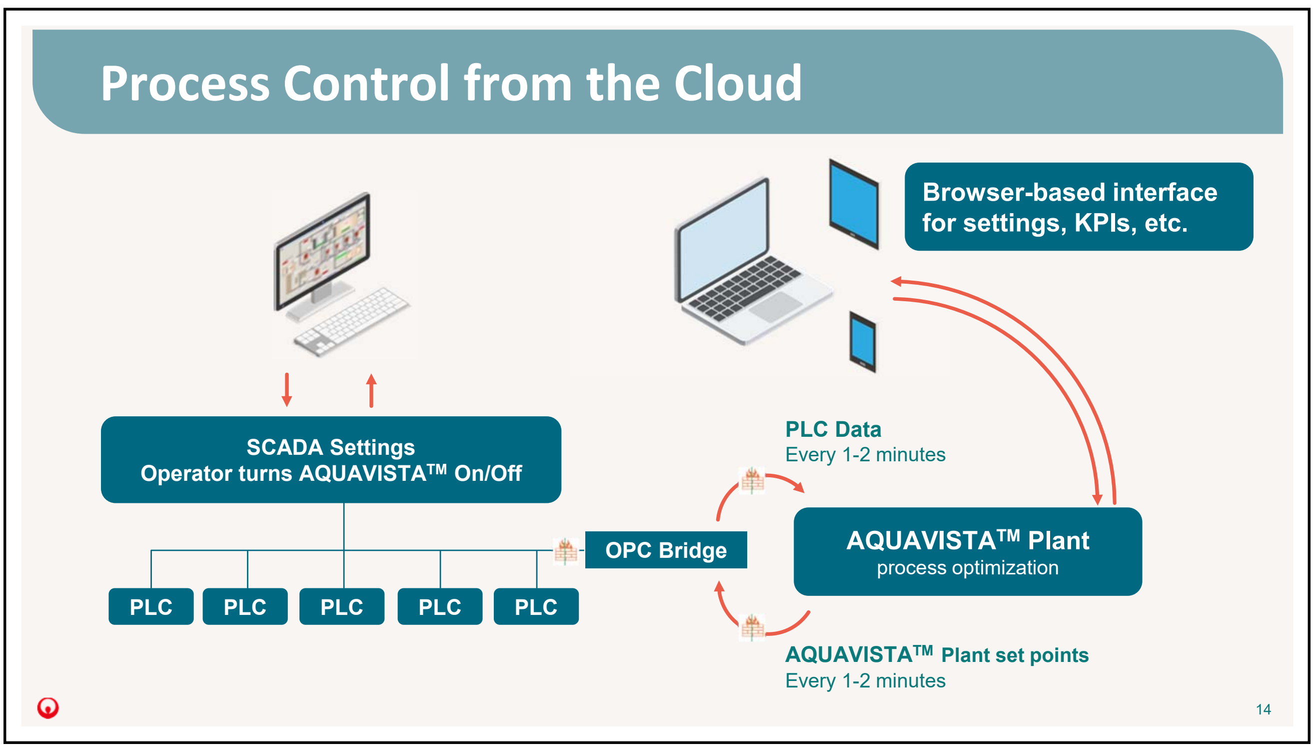
Process Control from the Cloud
Browser-based interface for settings, KPIs, etc.
SCADA Settings
Operator turns AQUAVISTA™ On/Off
PLC
PLC
PLC
PLC
PLC
OPC Bridge
PLC Data
Every 1-2 minutes
AQUAVISTA™ Plant
process optimization
AQUAVISTA™ Plant set points
Every 1-2 minutes
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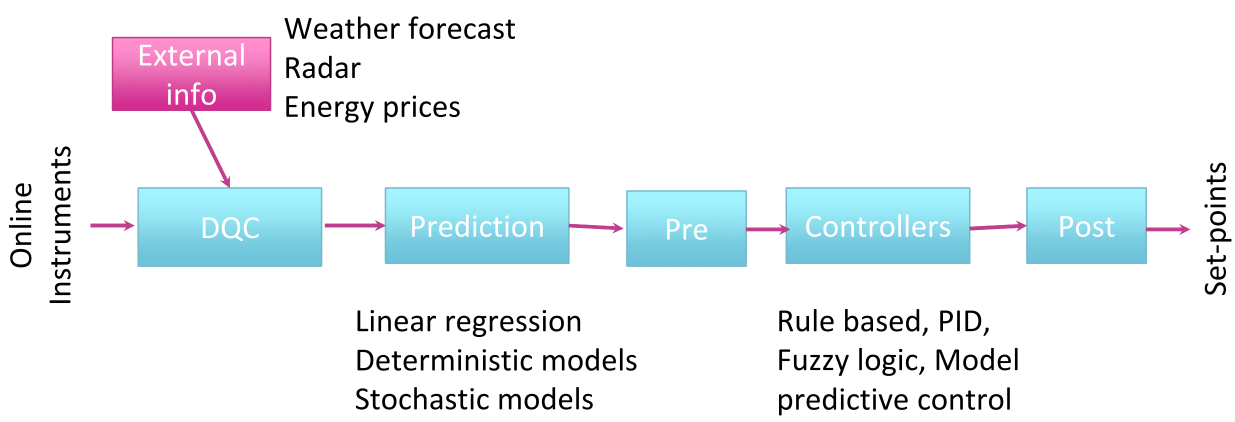
Structure of AQUAVISTA^{TM} Plant Algorithms



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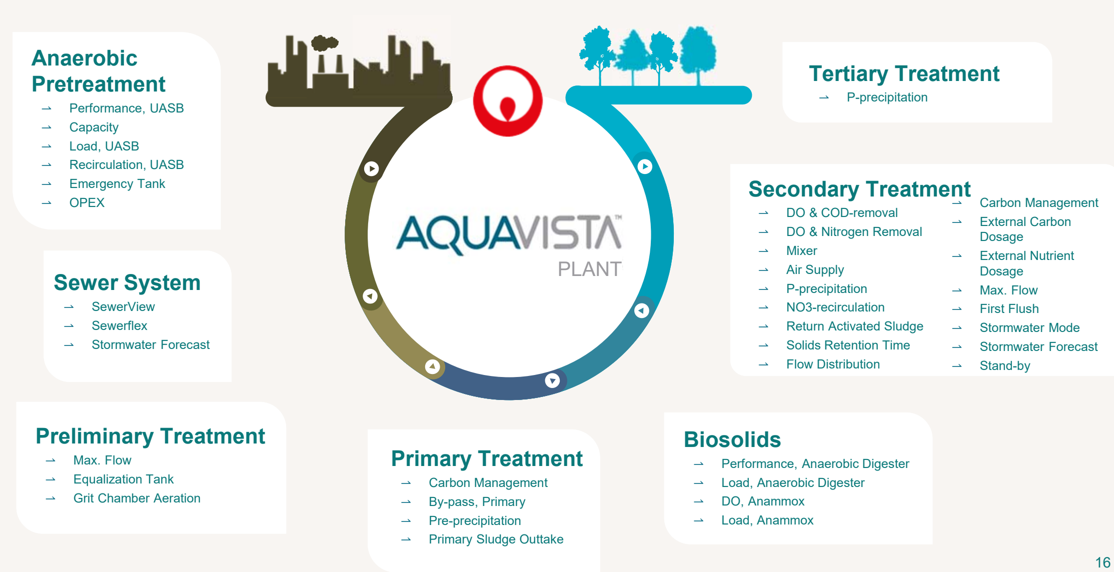
AQUAVISTA^{TM} Plant - Control Modules



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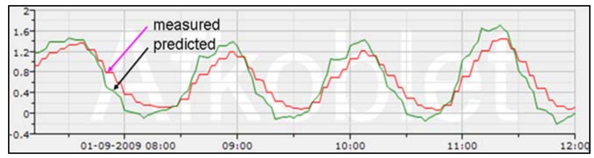
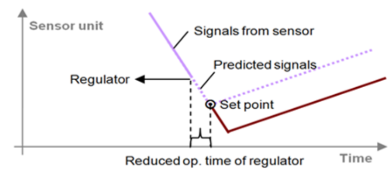
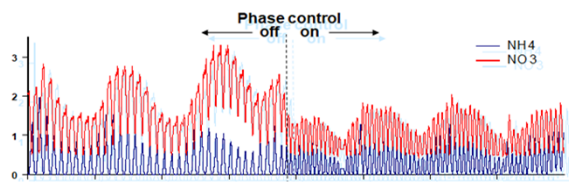
Example: N/DN phase control

- **Measurements**
  - *Flow + effl. NH_4-N + effl. NO_3-N + reactor DO*
  - *Multicriteria input to algorithms*
- **Outputs - Automatically Implemented into PLC**
  - *Operating Phase*
  - *DO Set Point (When in Aerobic Phase)*
- **Basic Strategy**
  - *More N-time (maybe 100 %) during high load*
  - *More DN-time in situations of low load*
- **Benefit**
  - *Maximize NO_3 (nitrate) used for BOD removal*
  - *Improved nitrogen removal*
  - *Highest energy efficiency possible*



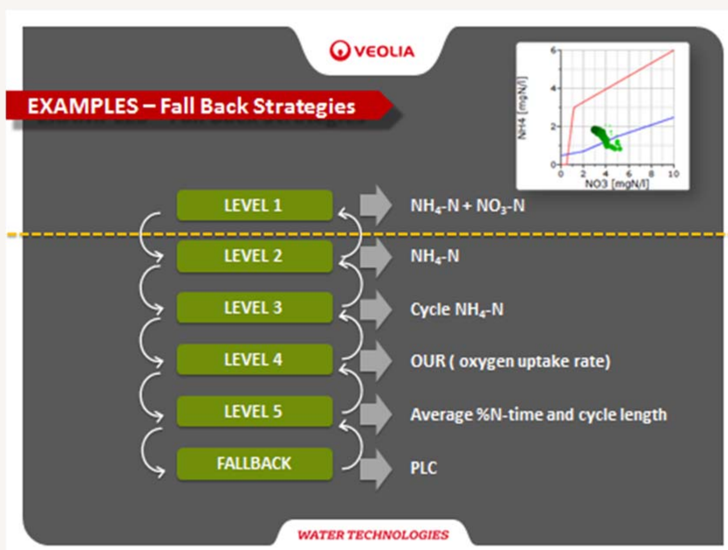




Automated Data Quality Checks

Multiple optimization levels with automatic switching

- Based on data quality check of sensor measurements
- Only data validated OK are used for optimization
- Example: DO & Nitrogen Removal



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AQUAVISTA™ Plant - Proven Results

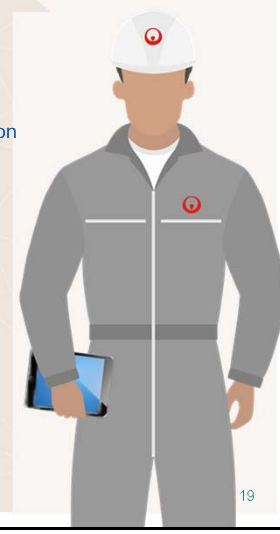
Less energy consumption
- Aeration | 10 – 30 %
- Mixing | 25 – 75 %
- Internal pumping | 25 - 75 %
- Grit chamber aeration I 20 - 90% + improved sand separation

Less chemical dosage
- P-precipitation | 20 – 100 %
- Dosage of COD, N & P | 25 – 100 %

Less chemical sludge production
- Less P-precipitation chemical dosage

More gas production in digesters
- up to +10%

Lower effluent concentrations
- Total-N | 20 – 50 %
- Total-P, BOD, COD, SS… | 0 – 50 %



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AQUAVISTA™ Plant - Results

Biological capacity
- 10 – 40 % more load
  - With same effluent concentrations as before
  - Less / avoided CAPEX for extension / upgrade
- Design & Build: Smaller volume of tanks needed
  - Less CAPEX

Hydraulic capacity
- 20 – 100 % higher flow through the WWTP
  - Less # of bypasses
  - Less / smaller retention basins in sewer network
  - Less / avoided CAPEX for extension / upgrade
- Design & Build: Smaller secondary settling tanks
  - Less CAPEX

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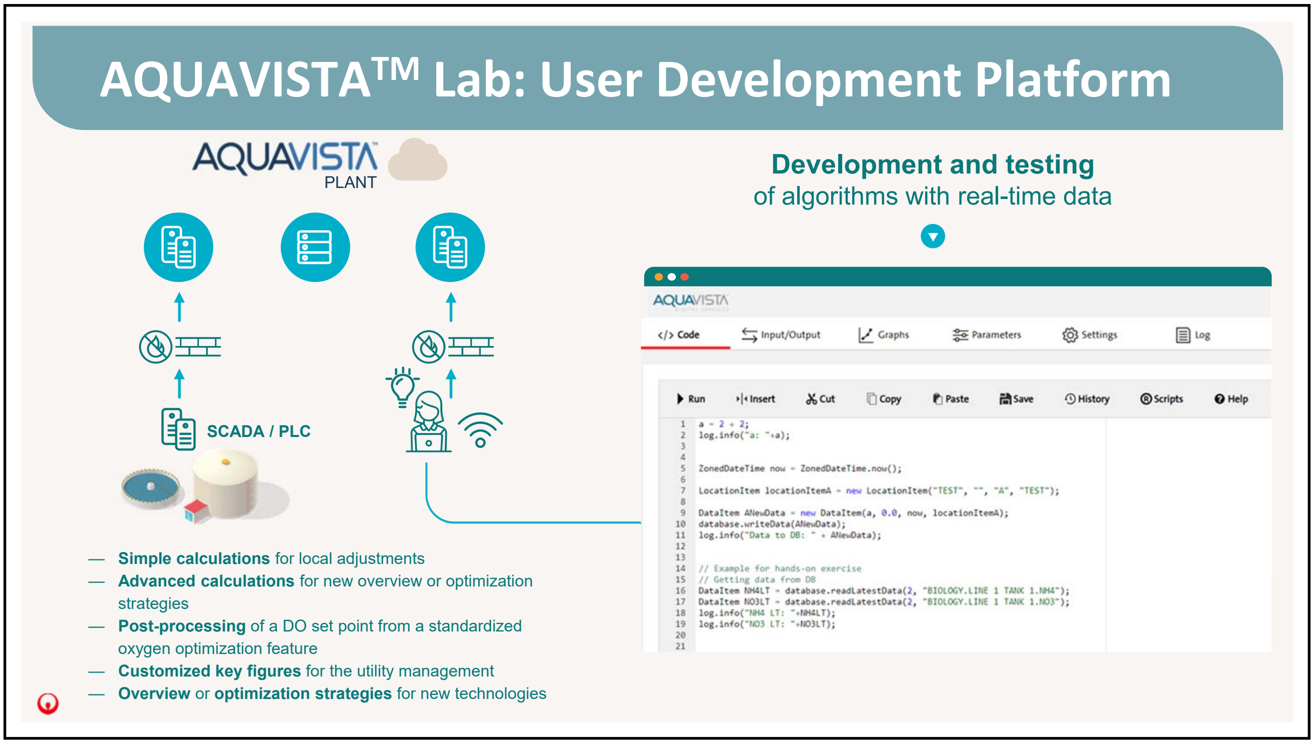
AQUAVISTA™ Lab: User Development Platform
AQUAVISTA PLANT
SCADA / PLC
Development and testing
of algorithms with real-time data
AQUAVISTA
Code
Input/Output
Graphs
Parameters
Settings
Log
Run
Insert
Cut
Copy
Paste
Save
History
Scripts
Help
a = 2 + 2;
log.info("a: "+a);
ZonedDateTime now = ZonedDateTime.now();
LocationItem locationItemA = new LocationItem("TEST", "", "A", "TEST");
DataItem ANewData = new DataItem(a, 0.0, now, locationItemA);
database.writeData(ANewData);
log.info("Data to DB: " + ANewData);
// Example for hands-on exercise
// Getting data from DB
DataItem NH4LT = database.readLatestData(2, "BIOLOGY.LINE 1 TANK 1.NH4");
DataItem NO3LT = database.readLatestData(2, "BIOLOGY.LINE 1 TANK 1.NO3");
log.info("NH4 LT: "+NH4LT);
log.info("NO3 LT: "+NO3LT);
— Simple calculations for local adjustments
— Advanced calculations for new overview or optimization strategies
— Post-processing of a DO set point from a standardized oxygen optimization feature
— Customized key figures for the utility management
— Overview or optimization strategies for new technologies

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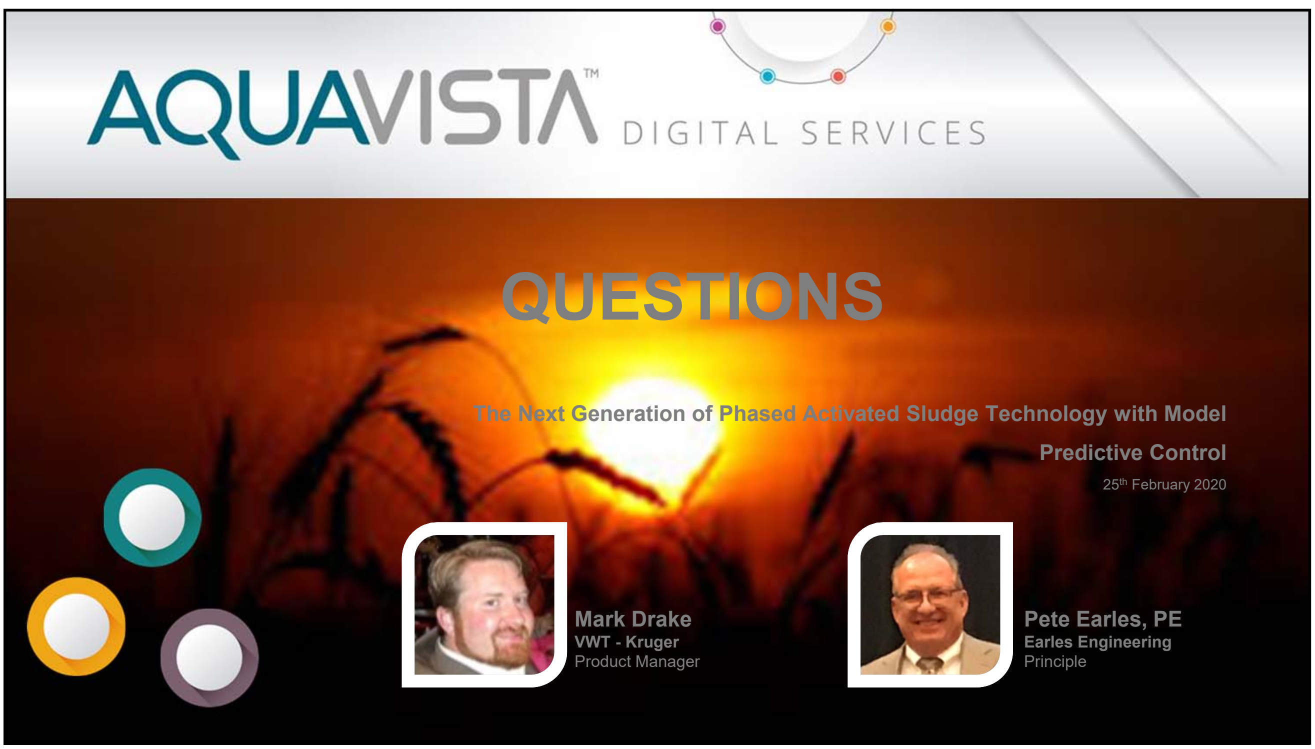
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QUESTIONS
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