Use of dynamic process control at a Long Island Sound Water Pollution Control Facility significantly reduces supplemental carbon use while maintaining nitrogen removal permit compliance

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Overview

Background on nitrogen trading in Connecticut

Nitrogen removal process at the Stratford WPCF

Use of nitrate analyzers

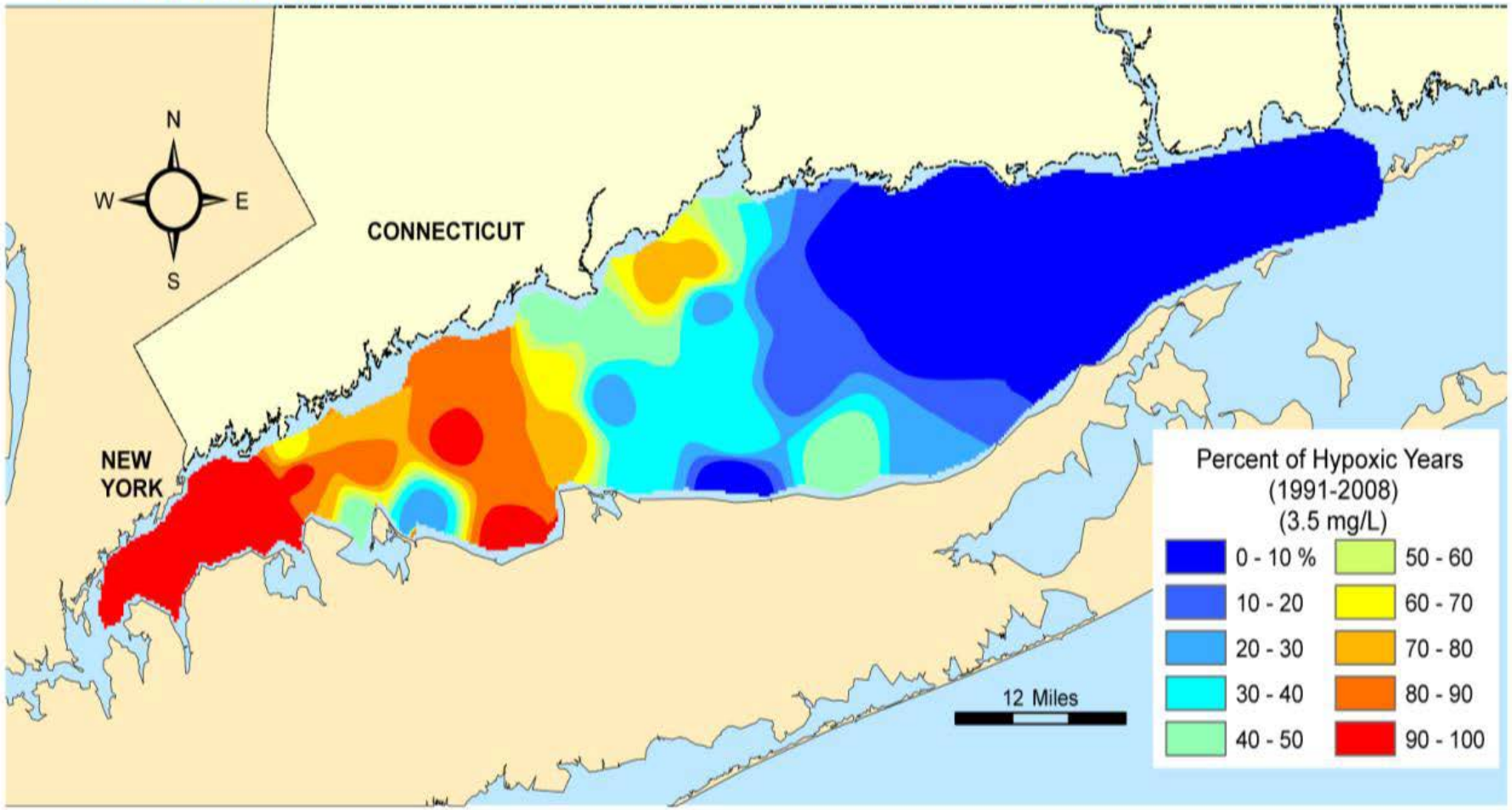
Process control system case study

Discussion of results

Conclusions

Background on nitrogen trading in Connecticut

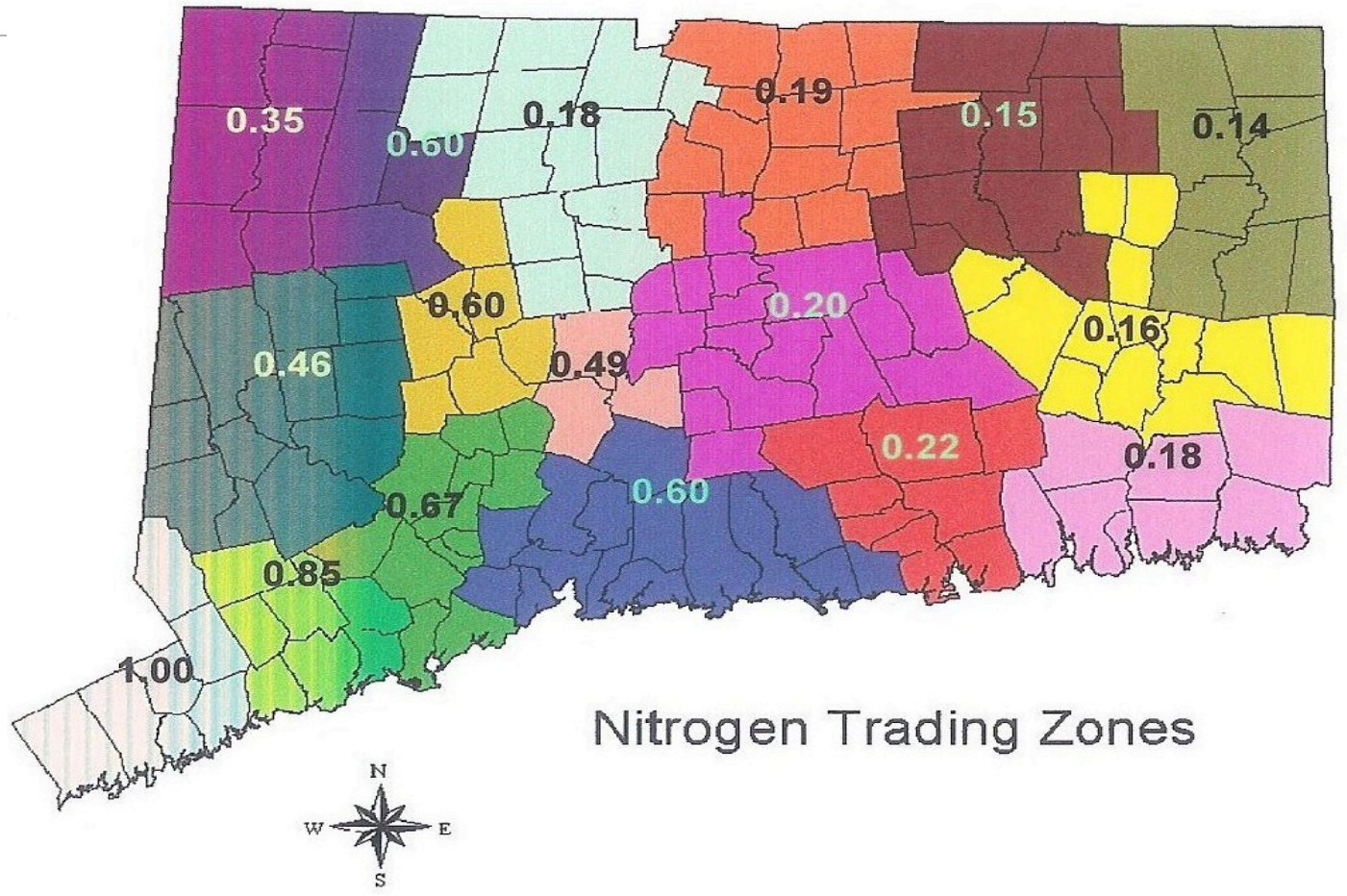
THE FREQUENCY OF HYPOXIA IN LONG ISLAND SOUND BOTTOM WATERS



Connecticut Nitrogen Trading Program and General Permit were initiated in 2002 as a result of the TMDL and WLA for Long Island Sound

- The General Permit provided annual mass based nitrogen limits for 79 POTWs in Connecticut.
- The annual mass based limits decreased each year from 2002-2014 when the final TMDL limit was achieved.
- POTWs are allowed to trade (buy and sell) credits based on the annual nitrogen mass removal performance.
- Trades are based on geographic trading zones. Stratford is located in zone 4 where the equivalent credit ratio is 0.67.
- The 2014 final limit for Stratford is 356 pounds per day.
- Changes to the program starting this year will limit the value of nitrogen credits sold to the amount of credits purchased in future years. This is estimated to reduce the value of credits sold by up to 70% by 2018.

Connecticut Nitrogen Trading Zones



Nitrogen removal process utilized at Stratford

Stratford WPCF

- **Located on Long Island Sound**
- **Plant design average annual flow: 11.5 mgd**
- **Process: 4 stage BNR facility**
- **Supplemental Carbon- 70% glycerol**
- **Nitrogen Limit is an annual mass based limit in pounds of total nitrogen per day.**
  - **356 #/d in 2014 (Final WLA Limit) or 5.4 mg/l TN at average annual flow of 8 mgd**
- **Stratford utilizes 5 Hach Nitratax online nitrate analyzers to monitor the process.**
- **Control is through a feed forward process control with a feed back effluent NOx trim through a PID.**

BNR Process Tanks

Stratford 2nd anoxic zones

Supplemental carbon storage and feed system

Tote transfer tank

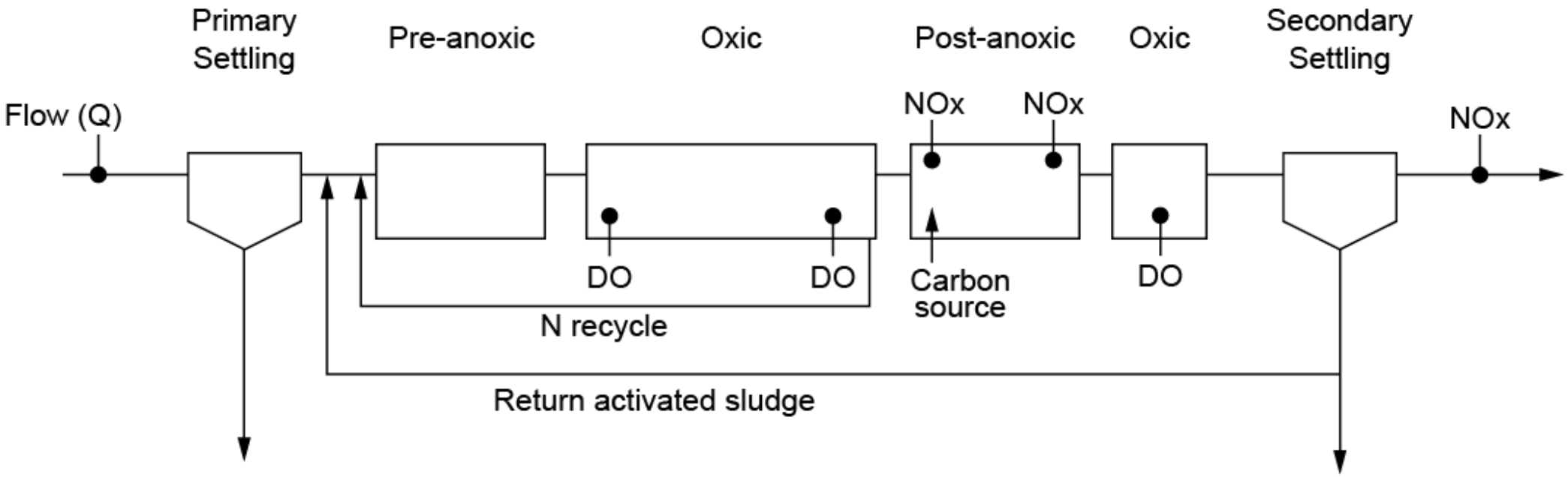
Supplemental carbon feed pumps and bulk transfer pump

Online analyzers and locations

Stratford online analyzers

	Manufacturer	Model	Locations	Use of Data
DO	HACH	LDO	upstream and downstream ends of oxic zones, reaeration zone	Control of aeration rate
NOx	HACH	NITRATAX	upstream and downstream ends of post-anoxic zone and at the final effluent sampling well	Real-time control of external carbon dosing rate

Stratford BNR process with analyzer locations



Nitrate analyzer locations in the 2nd anoxic zone

Final effluent sampler

Process control system case study

Why and what type of control to use

Control is about adjusting dynamic systems in order to reach a specific goal.

The fundamental components of a control system are:

- Sensors
- Actuators
- Controllers

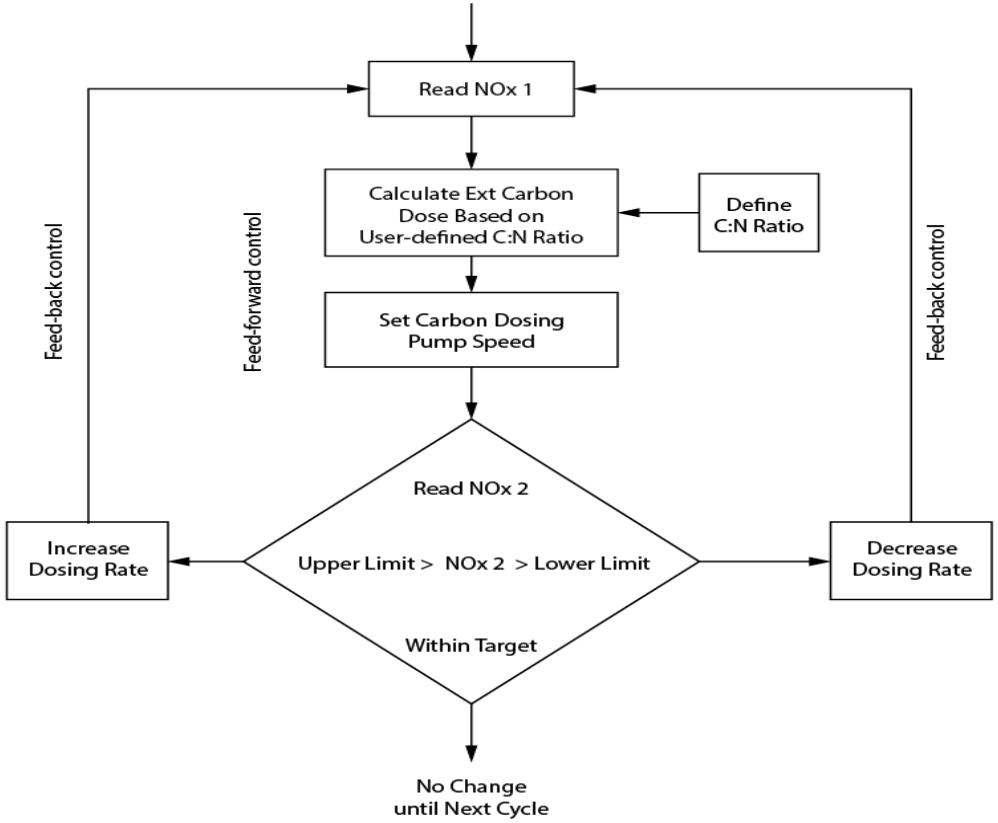
Feedforward control (use of a specific algorithm which is specific to the process)

Feedback control

PID controllers

- Proportional term
- Integral term
- Derivative term

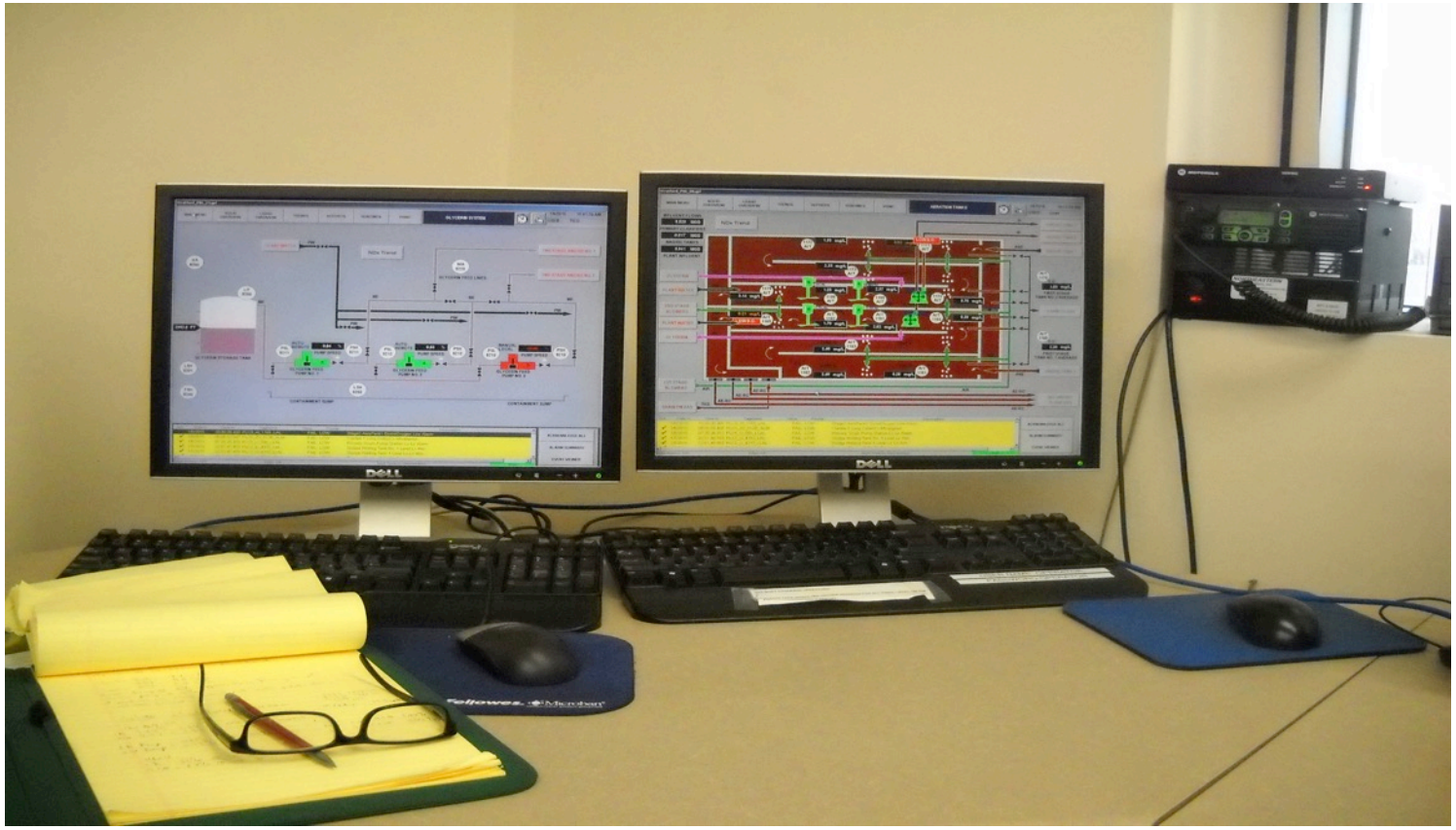
Process control logic



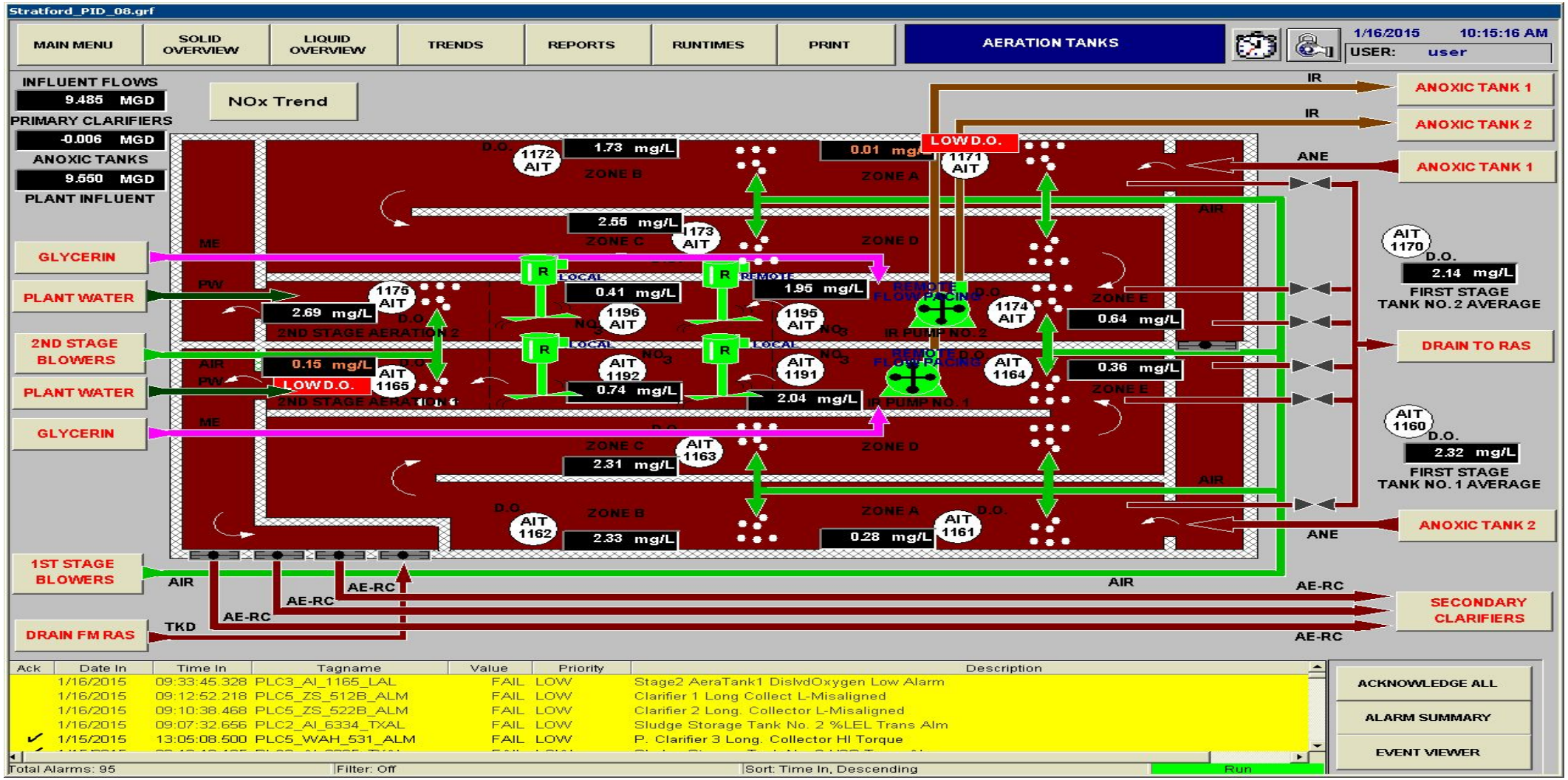
Nitrate removal control algorithm

- Calculates loading based on forward nitrate analyzers
- Creates a ratio using set point error
- Adds chemical based on flow and loading
- When the optimal feed forward ratio is achieved the final process trimming function is accomplished with a PI controller from final nitrate analyzer.

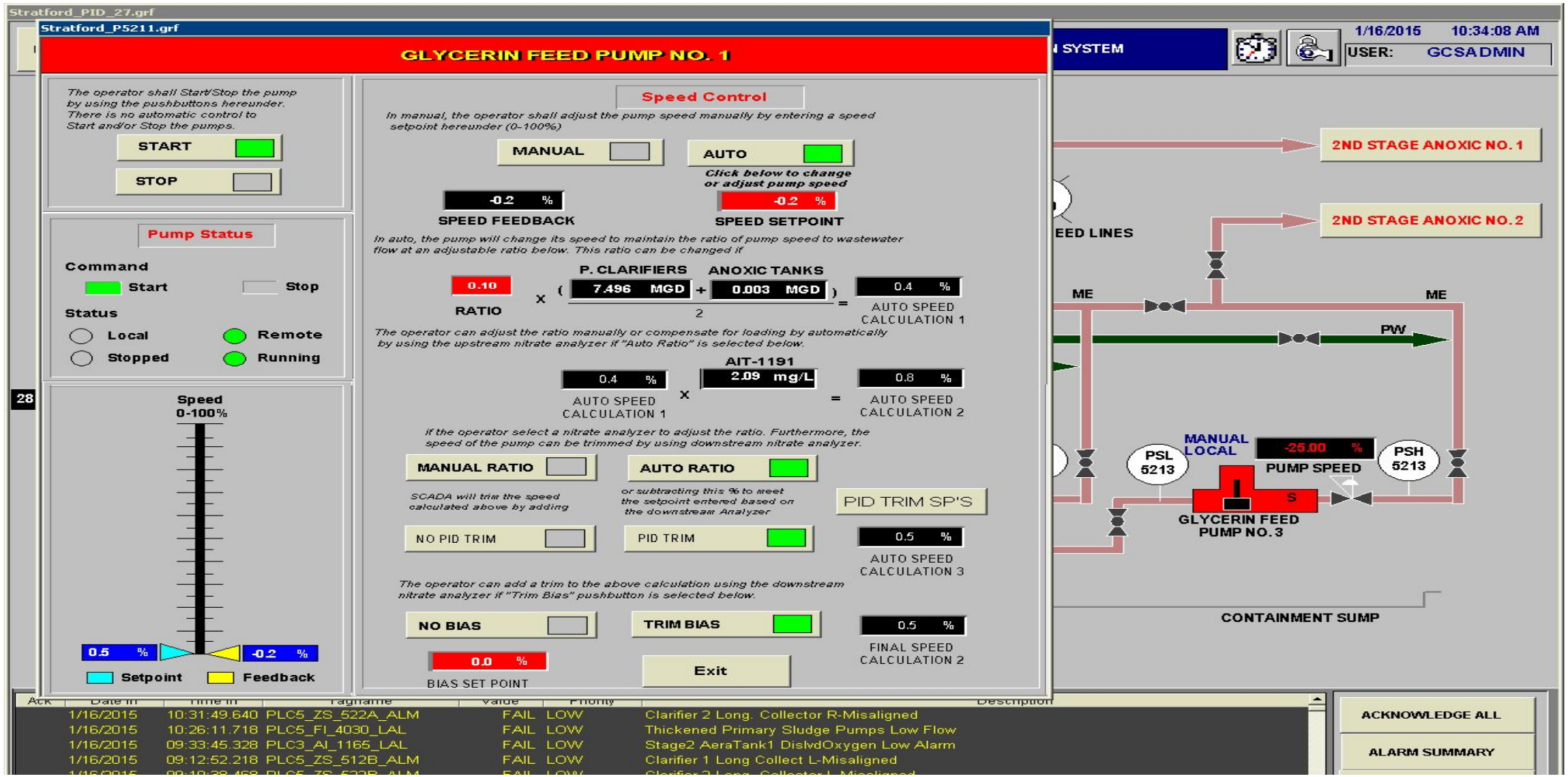
SCADA control display



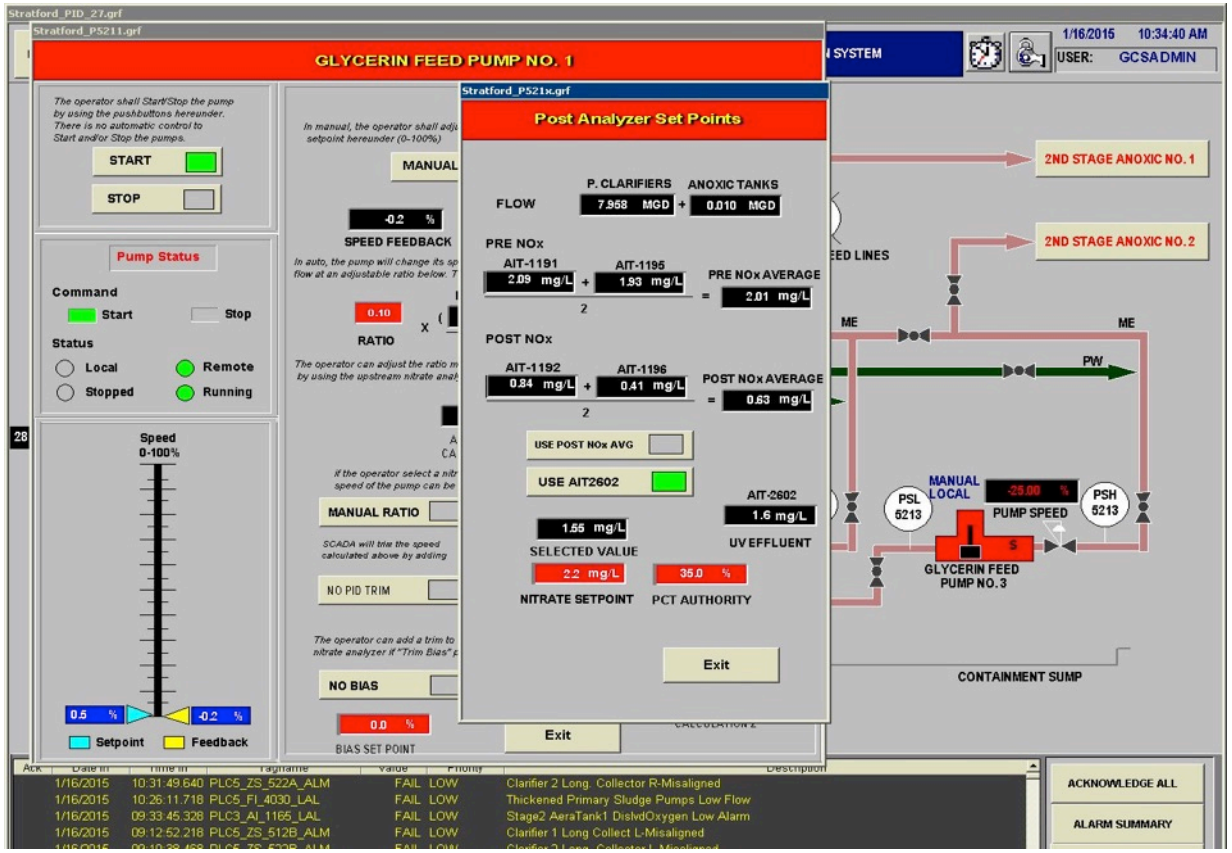
BNR Process SCADA screen



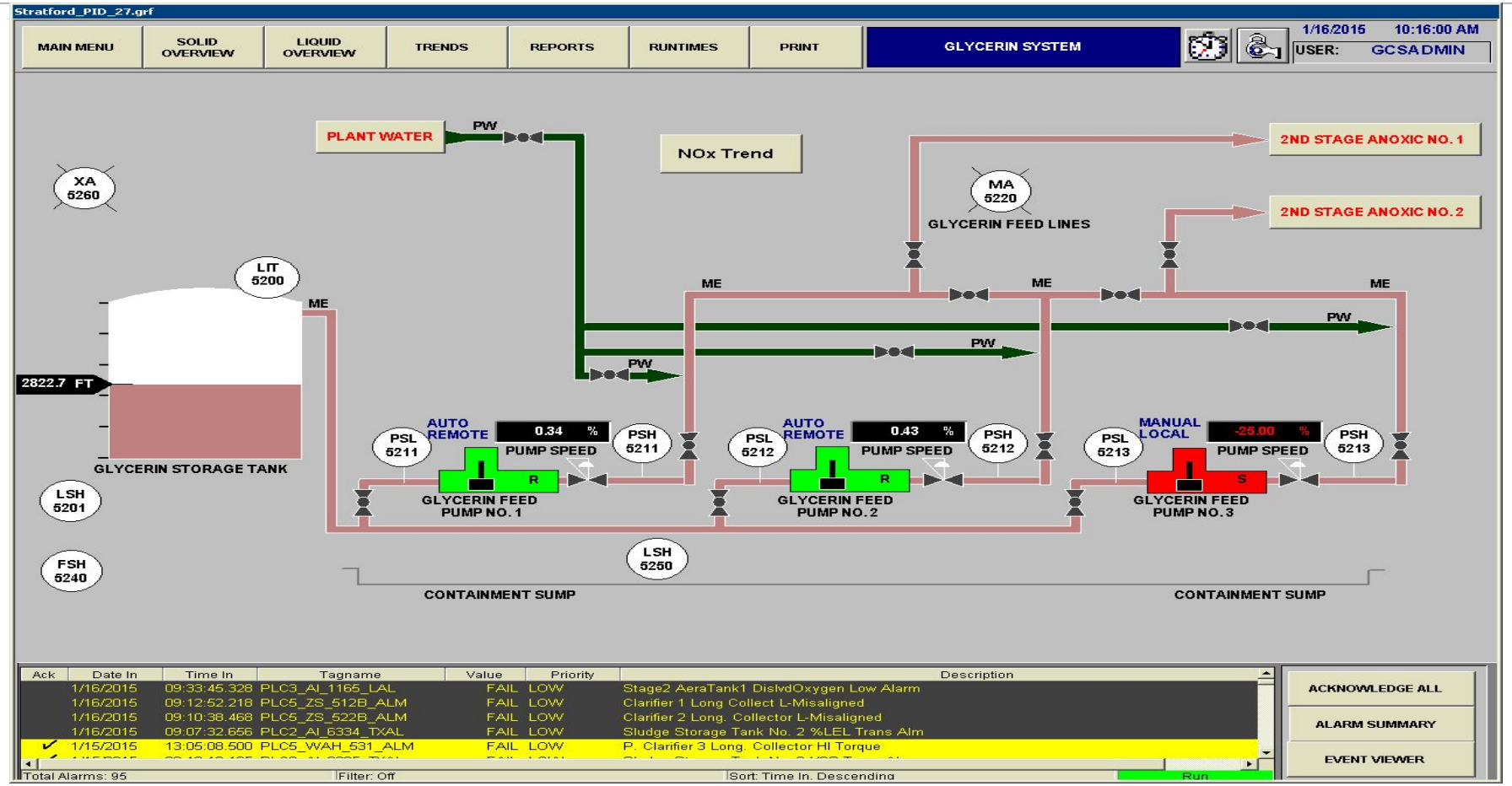
Glycerol feed pump control



Effluent feedback trim PI



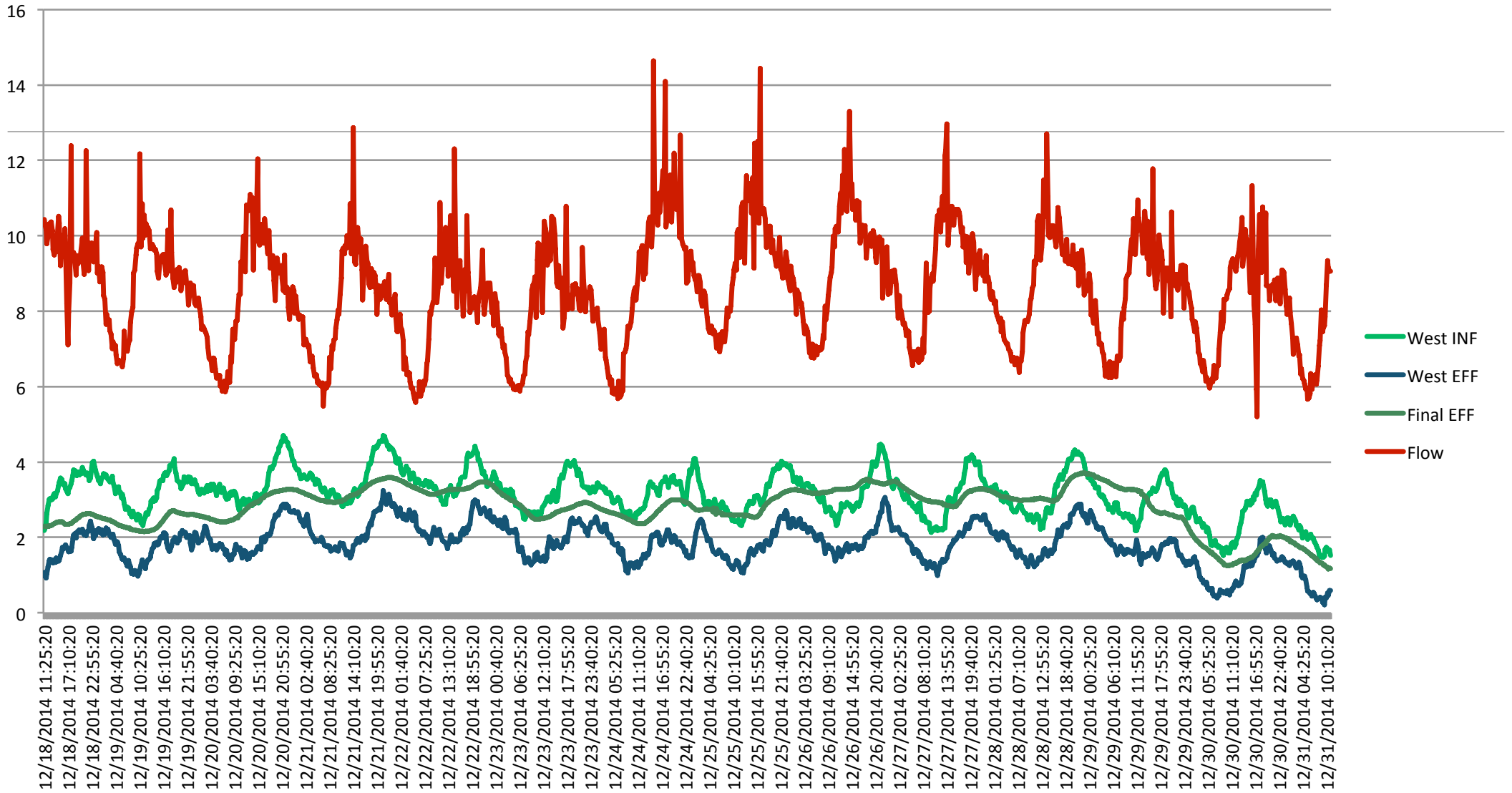
Tank and pump information



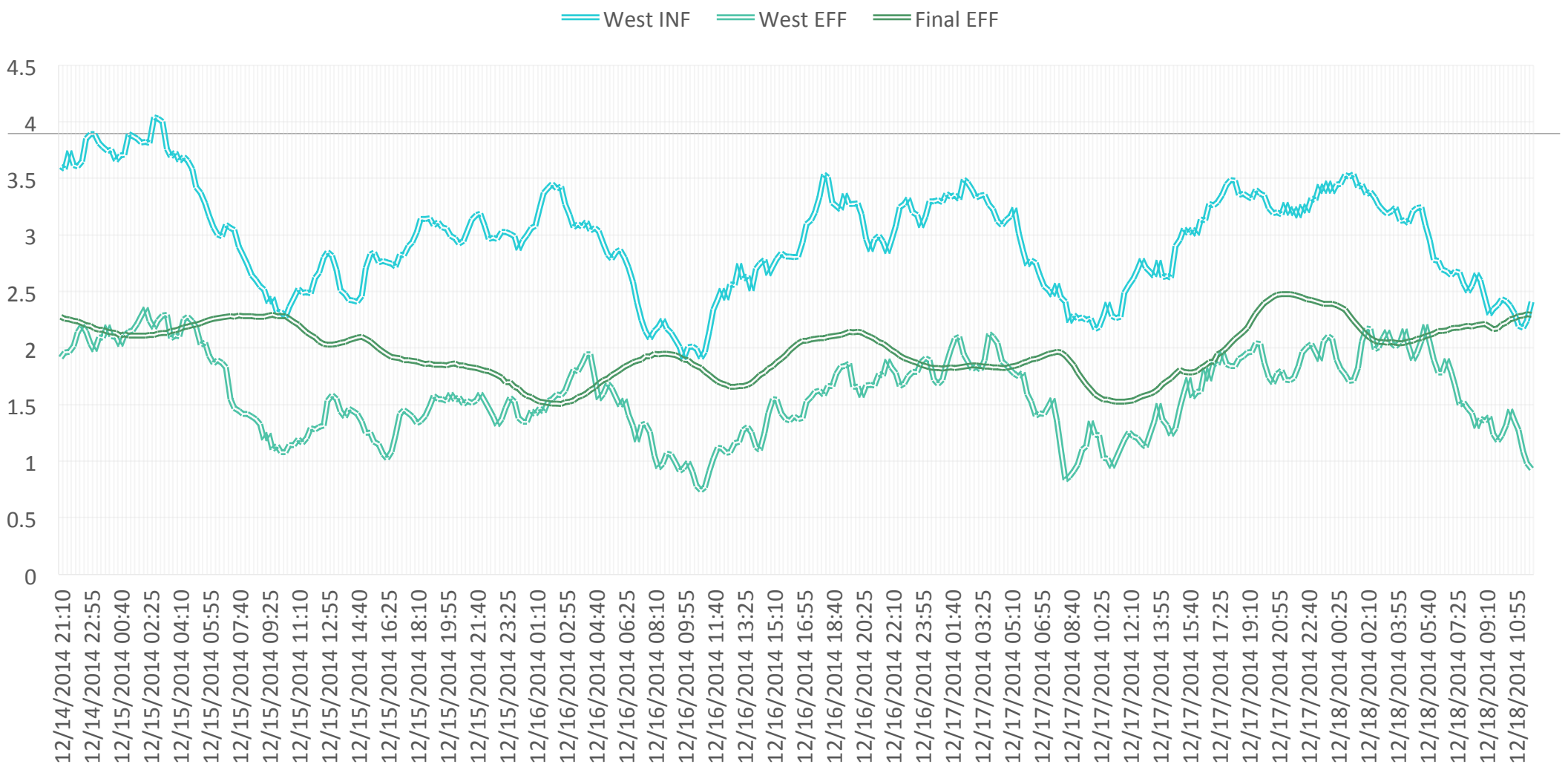
Evaluation and Optimization Period
June 2014-December 2014

- Supplemental Carbon Use was 10,800 gallons for all 2014
- Supplemental carbon use in 2011 was 150 gpd without control and <30 gpd in 2014 with process control.
- Previous Supplemental Carbon use in 2011 before optimization was 54,000 gallons and 43,000 gallons in 2012
- Average use reduction from the 2011 year to 2014 was 43,200 gallons per year or an 80% overall reduction in chemical use for an annual savings of $75,600
- Average mass based total nitrogen discharged June - December 2014 was 206 pounds per day with optimized supplemental carbon use.
- Average mass based total nitrogen discharged June – December 2011 was 219 pounds per day with high supplemental carbon use and little control.
- 2014 mass permit = 356 pounds per day
- A net savings of 150 pounds per day or 31,500 pounds for the evaluation period below the permit limit was achieved.
- Average total nitrogen discharged was 3.96 mg/l for the evaluation period

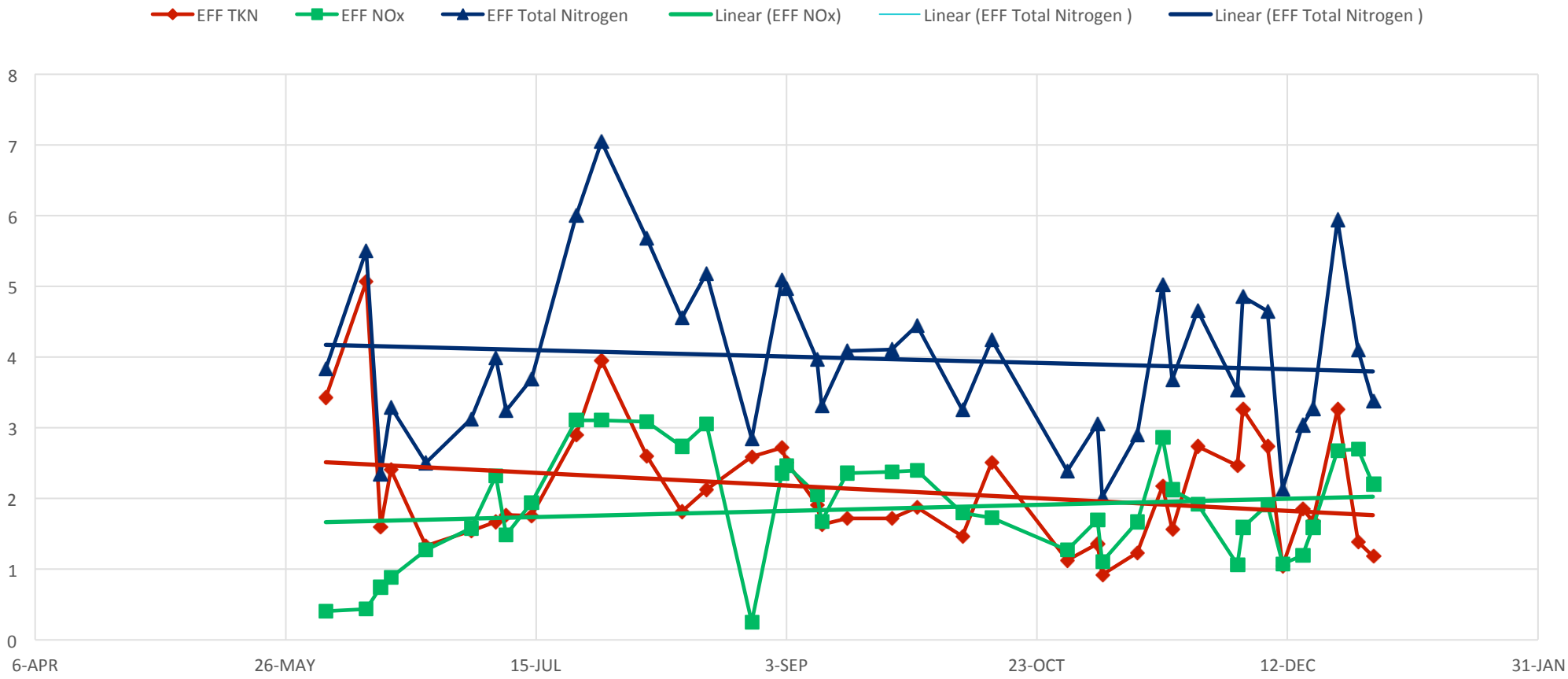
West process train nitrogen data and plant flow: December 18-31, 2014



West process train nitrogen data: December 14-18, 2014



STRATFORD
EFF NITROGEN
JUNE-DEC 2014
DAILY COMPOSITE DATA



GENERAL CONTROL SYSTEMS - SYSTEM HIGHLIGHTS

- System can be self-contained or part of a plant SCADA system
- System can be monitored or adjusted remotely
- System has data logging and alarming
- Data can be extracted or hosted on a web page
- Sensors can be wired or wireless

Lessons learned and things to consider

- Assume the flow balance between process trains will **not** be equal and adjustment to either the influent gates or the process control will be necessary to balance the system performance.
- Adjustment of the internal recycle is necessary to maximize the overall process performance.
- Adjustment to the DO control system will be needed to reduce DO levels into the post anoxic zone but high enough to completely nitrify in the oxic zone.
- Understand that each wastewater treatment plant is unique with respect to flow and loading patterns and trends.
- Observe the process to check and calibrate your analyzers.
- Have a high flow wet weather plan to allow operation of the process without washout of nitrifiers

Conclusions

- Installation of the Nitratax online nitrate analyzers provided a better understanding of the daily fluctuations in nitrogen loading to the post anoxic zone which allowed for better nitrogen control.
- Utilization of an automatic flow proportioned feed forward control system utilizing online nitrate analyzers provided the optimal nitrogen removal and most efficient use of supplemental carbon.
- Overall supplemental carbon use was reduced by >75% from the 2011-2012 operating years without online control from 150 gpd down to <30 gpd.
- This resulted in an average annual chemical savings of >$66,000/year over the 2011-2012 operating years without full process control.
- Nitrogen removal at Stratford was excellent with total nitrogen discharged at <4 mg/ for the June – December evaluation period.
- Optimization of supplemental carbon use through process control enhancements will help to offset the reduced value of nitrogen credits sold with the Connecticut nitrogen trading program changes taking effect in 2015.

Optimize the system but beware that under the most rigorously controlled conditions of temperature, pH, volume, loading, and other variables, the microorganisms will do as they damn well please!!

Questions?

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