BENEFITS OF ON-LINE CHEMISTRY ANALYZERS FOR MONITORING AND CONTROL OF ADVANCED WASTEWATER TREATMENT SYSTEMS

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Brief Outline

- Applications and Case Studies
  - Nitrification
  - Denitrification
  - Phosphorous Removal
    - Biological
    - Chemical
- UV Disinfection Control
- Case Study BardenPho BNR Process

“If You Want to Control Process Chemistry, Measure Process Chemistry”

- If a plant has nitrogen and/or phosphorus discharge limits then why measure anything other than nitrogen and phosphorus for process control ?
- Surrogate parameters such as Dissolved Oxygen, Alkalinity and Respirometry do not provide any real information about nutrient levels.

Technology Overview

On-line Process Monitoring Requirements

- Analysis of multiple nutrients
- Monitoring of multiple sample points
- Fast response to concentration change
- Tolerance for background chemistry change
- Minimal sample conditioning
- Automatic operation
- Low maintenance

Nitrification Examples

- Secondary effluent analysis
  - Edmonton AB, Calgary AB, Mesa Az
  - Less immediate time interval
  - Low solids samples after clarifier
- Aeration basin analysis
  - Gainesville FL, Lexington KY, Orlando FL
  - Real time analysis

Applications and Cases

- Nitrification
  - Converts ammonia to oxidized nitrogen
  - Initial conversion from ammonia to nitrite (NO_2)
  - Final conversion from nitrite to nitrate (NO_3)
- Calls for analysis of the full Nitrogen profile

Nitrogen Transformations During Nitrification

- Decline in ammonia from max to zero
- Increase, then decline in nitrite concentration
- Increase of nitrate to stable maximum
- Only AFTER this is any surplus DO produced

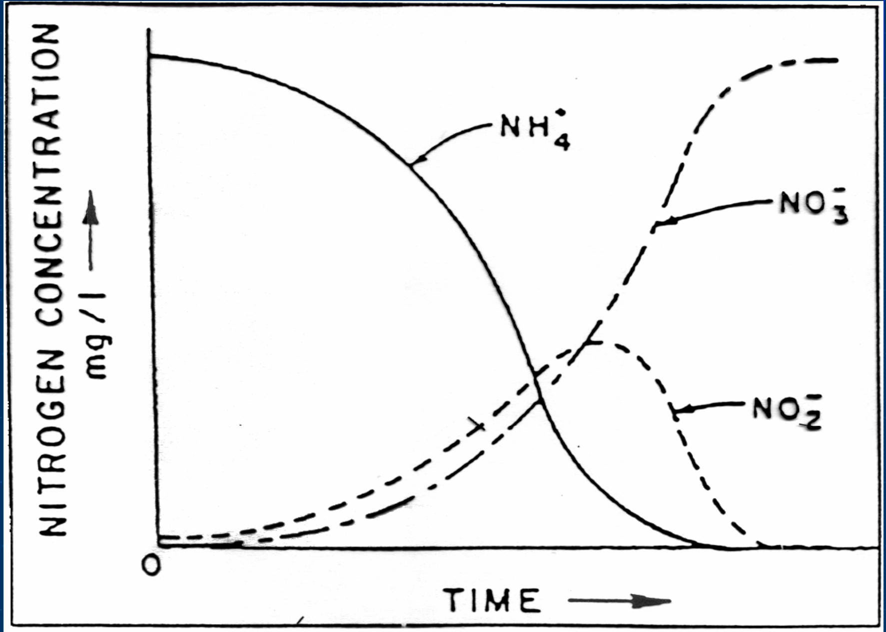
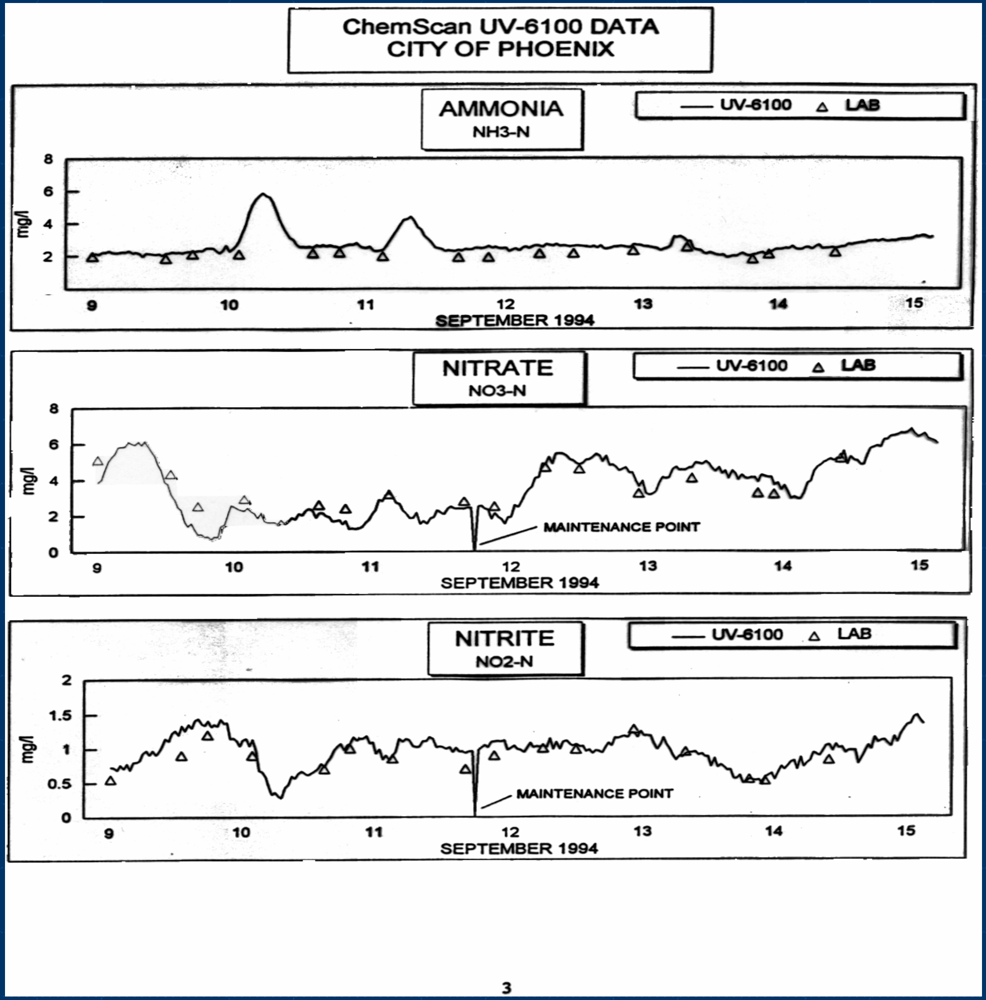


Figure 4. Schematic of nitrogen transformations during noninhibited nitrification, batch experiment.

Use Nitrogen Profile to Spot Process Upsets

- Decline in nitrate from steady state
- Increase in nitrite concentration
- Both occurred prior to increase in ammonia



Applications and Cases

- Denitrification
  - Converts nitrate to nitrogen gas
  - Initial conversion from nitrate to nitrite
  - Final conversion from nitrite to nitrogen gas
  - Biological stripping of oxygen atom, uses carbon as food source

Denitrification Process Examples

- Separate tanks after nitrification
  - Suspended growth
    - Blue Plains, VA
  - Attached growth
    - Tampa FL, Havelock NC, Scituate MA
- Separate tanks before aeration
    - Orlando Conserv II
- Circular tanks with zone control
    - Orlando Iron Bridge

Denitrification Process Variables

- High DO will retard or delay (object is to force microbes to strip oxygen from nitrite or nitrate
- Needs carbon source
  - "Front end" processes use natural carbon content of wastewater
  - "Back end" processes may require supplemental carbon (typically methanol)

Denitrification Control Strategy

- Front end processes
  - Assure complete nitrification by monitoring prior to return flow
  - Manage return flow fraction
  - Assure complete denitrification by monitoring reactor effluent

Denitrification Control Strategy

- Back end process
  - Assure complete nitrification by monitoring nitrogen profile in aeration basin
  - Calculate methanol feed rate by monitoring nitrate and nitrite in denitrification influent (may also need flow, temperature, DO)
  - Trim methanol feed rate by monitoring nitrate and nitrite in denitrification effluent (target is very low nitrate and no nitrite)
  - Avoid underfeed (starves biology) and avoid overfeed (increases BOD measurement)

Applications and Cases

- Phosphorous Removal
  - Phosphorous is essential for biological reproduction
    - Limit P in wastewater discharge to avoid unwanted microbiological growth in receiving bodies
    - Avoid nutrient deficiency within the biological treatment process
- Phosphorous removal requires good control

Phosphorous Removal Processes

- Biological
  - Facultative microbes
  - Release in anaerobic stage
  - Uptake in aerobic stage
  - Front end or side stream

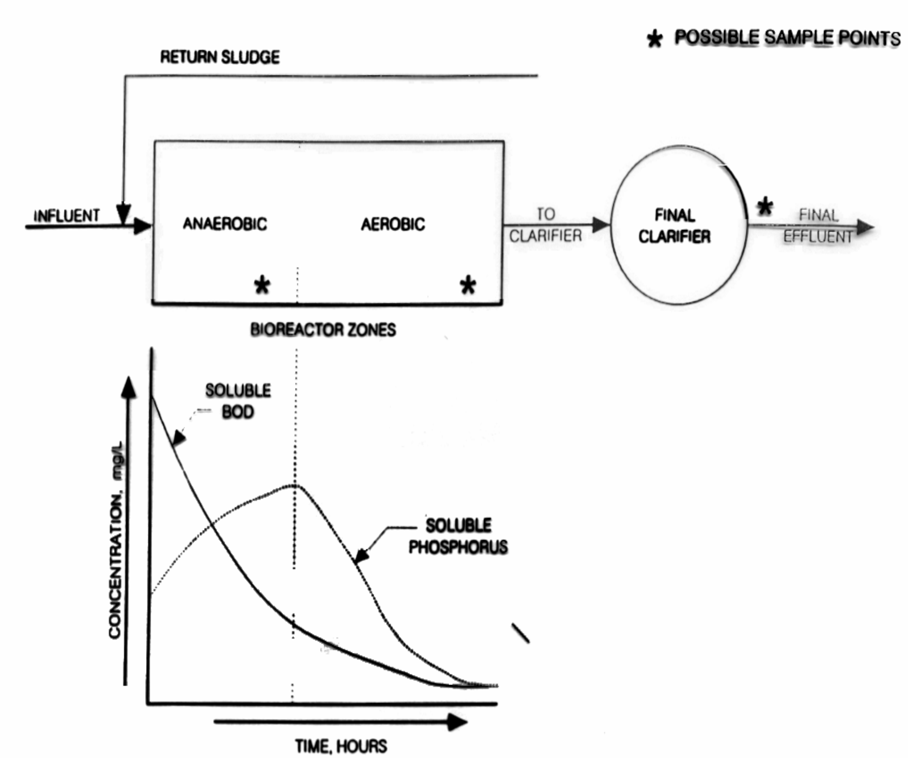


Figure 1. Soluble Biochemical Oxgen Demand and Phosphorous in Bioreactor
(Source: WEF Manual of Practice MOP 11, Operation of Municipal Wastewater Treatment Plants)

Biological Phosphorous Removal Control

- Monitor phosphorous release (as ortho-phosphate) in anaerobic reactor or effluent
- Monitor phosphorous load as ortho-phosphate in aeration basin influent
- Confirm luxury uptake by monitoring ortho-phosphate in aeration effluent
- Decide if chemical polishing is required
- Volatile Fatty Acid addition control
- Examples:
  - Orlando Iron Bridge, Lexington, KY, McDowell Creek NC

Phosphorous Removal Processes

- Chemical
  - Precipitate formation
  - Uses alum, lime, iron salts
  - Removal by sedimentation or filtration
  - Can be added at various process locations

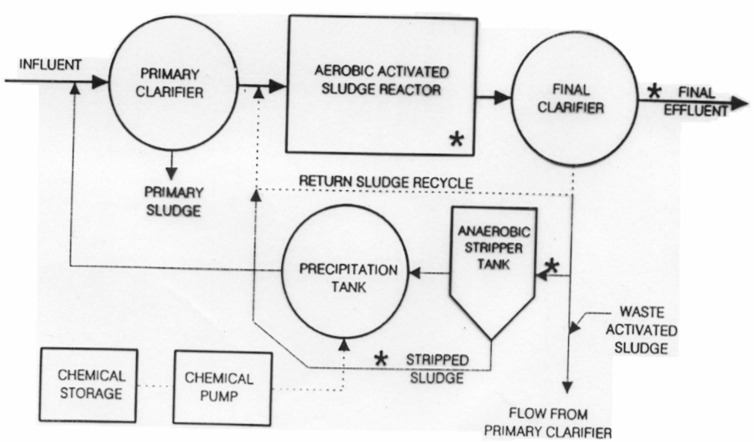


Figure 2. Sidestream Process for Biological Phosphorus Removal
Source: WEF Manual of Practice MOP 11, Operation of Municipal Wastewater Treatment Plants)

Chemical Phosphorous Removal Control

- Monitor influent phosphorous demand
  - Primary tank may not be ideal location
    - Polyphosphate conversion to orthophosphate requires time and enzymes (may be OK after equalization tanks or if long incoming lines)
    - Danger of creating phosphate deficiency
  - Calculate feed rate for precipitant
    - Varies with each chemical
    - May also vary with temperature

Chemical Phosphorous Removal Control (cont)

- Monitor Phosphorous concentration as ortho-phosphate after sedimentation or filtration
  - Use to trim coagulant feed rate
  - Excess coagulant may be harmful to downstream processes
- Monitor total phosphorous in the final effluent (catch dissolved plus overflow fractions)

Applications and Cases

- UV Disinfection Control
  - Independent measurement of UV absorbance or percent transmittance before and after UV disinfection
  - Avoids issues resulting from UV lamp age, fouling of lamp or internal sensor
  - Can pace lamps by measurement of incoming organic load

UV 254 Measurement Requirements

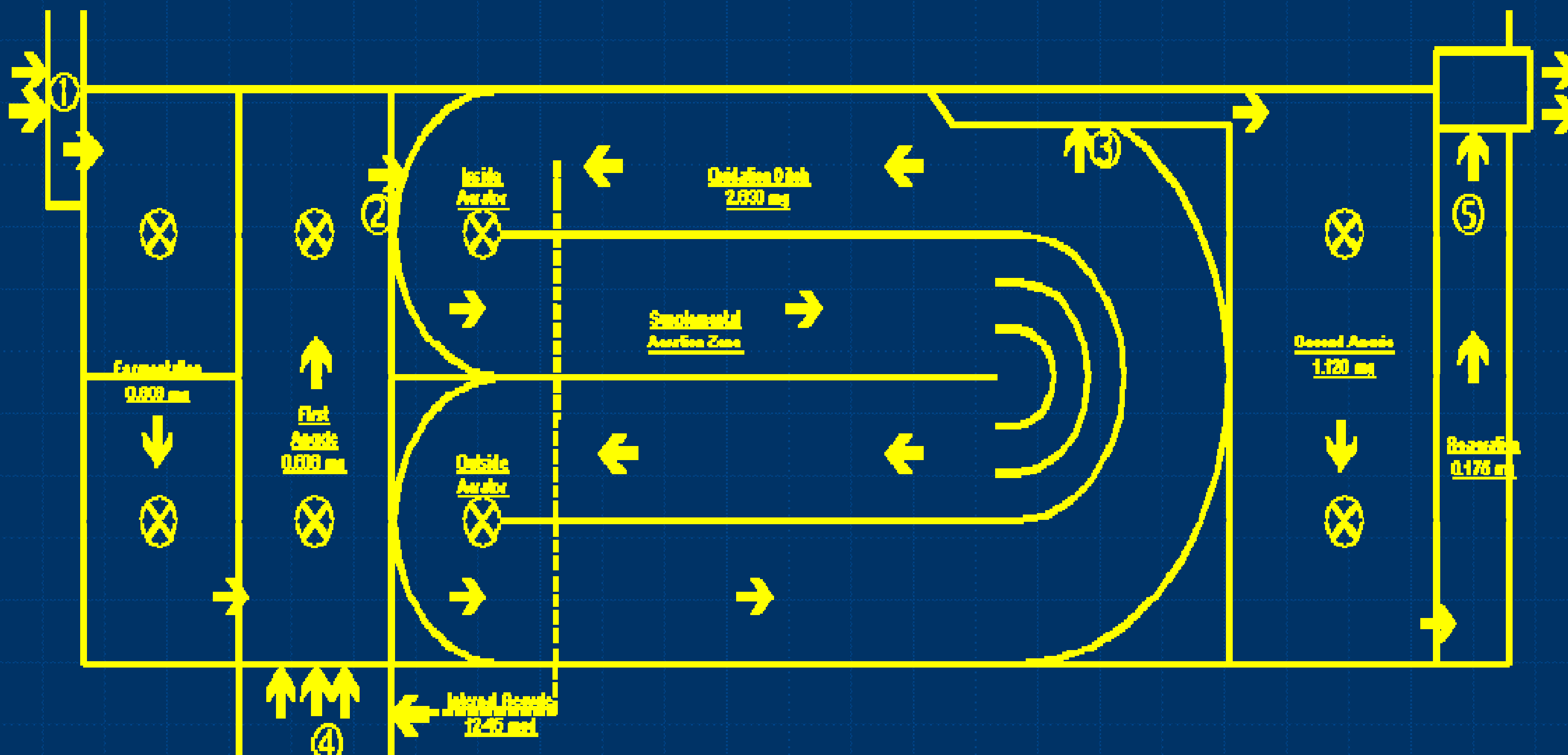
- Known lamp output measured prior to sample
- Avoid condensation cell windows
- Avoid fouling of cell windows through frequent zero and clean
- Avoid maintenance by automating zero and clean cycles
- Optional turbidity subtraction

Case Study

5 Stage BardenPho BNR Process

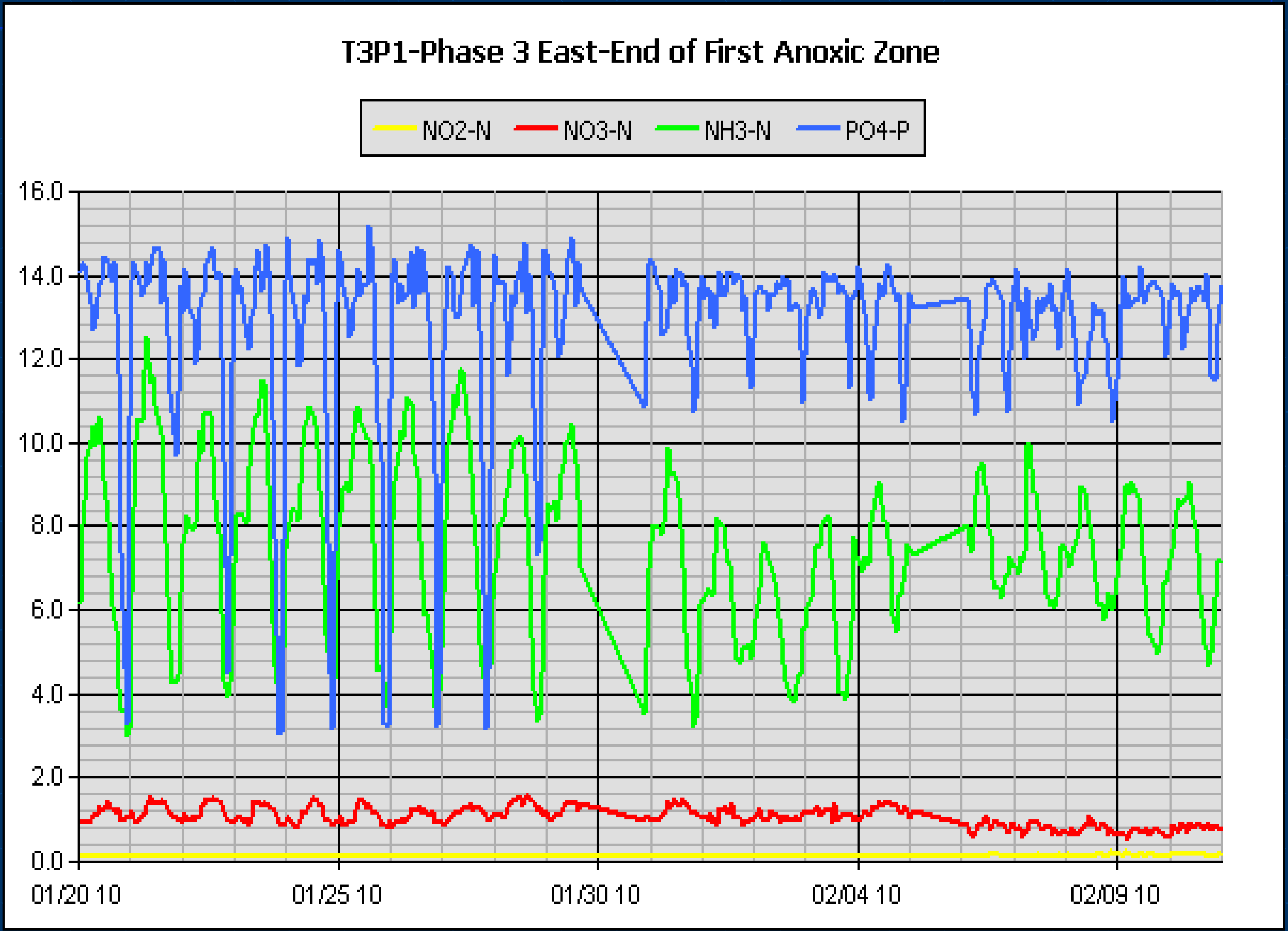
Monitoring System

- One analyzer system measuring NH3-N NO3-N NO2-N and PO4-P
- Six submersible pumps (three in two parallel processes)



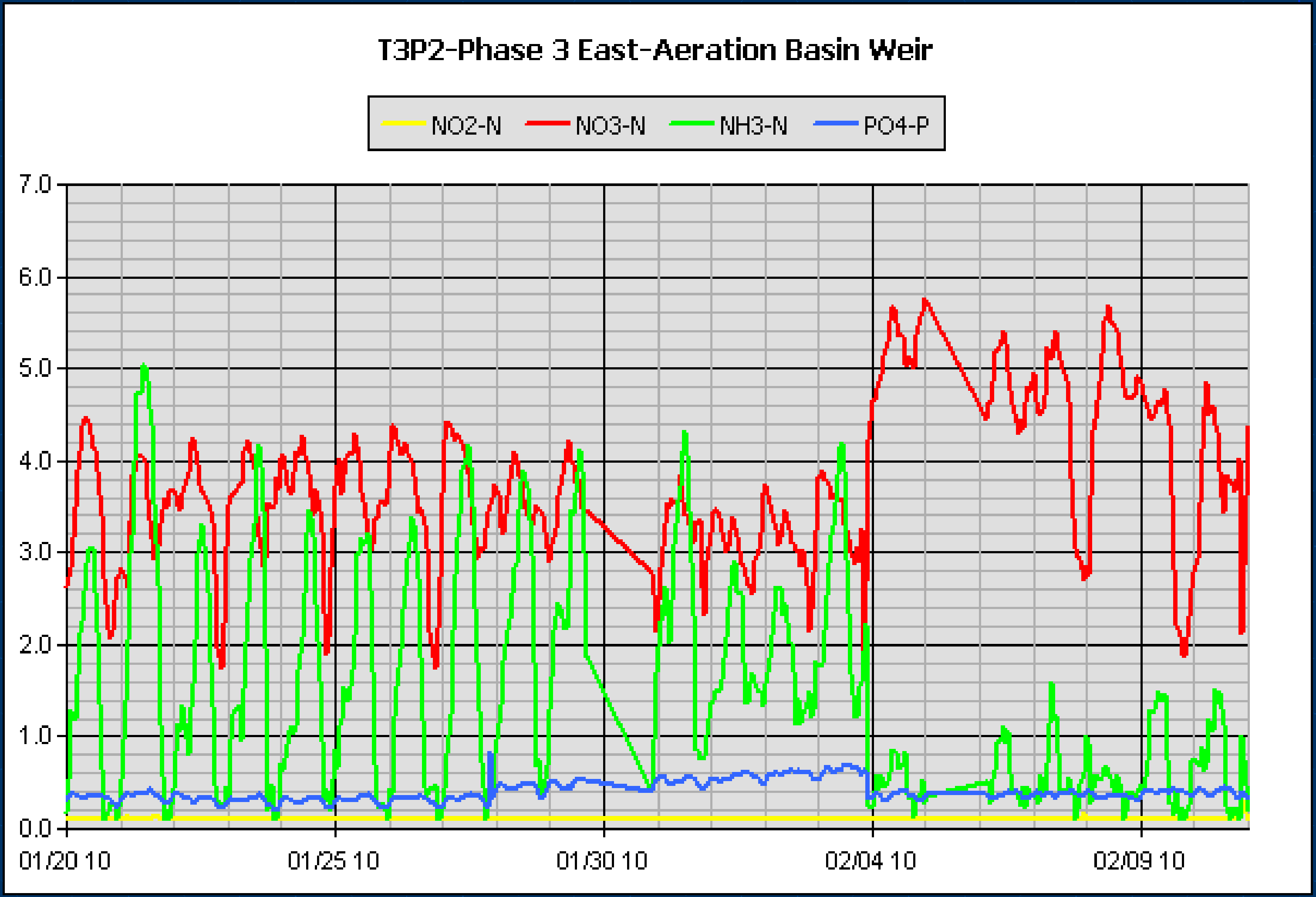
BardenPho Sample 1 Anoxic Zone

- High NH3
- High PO4
- Low NO3
- Low NO2



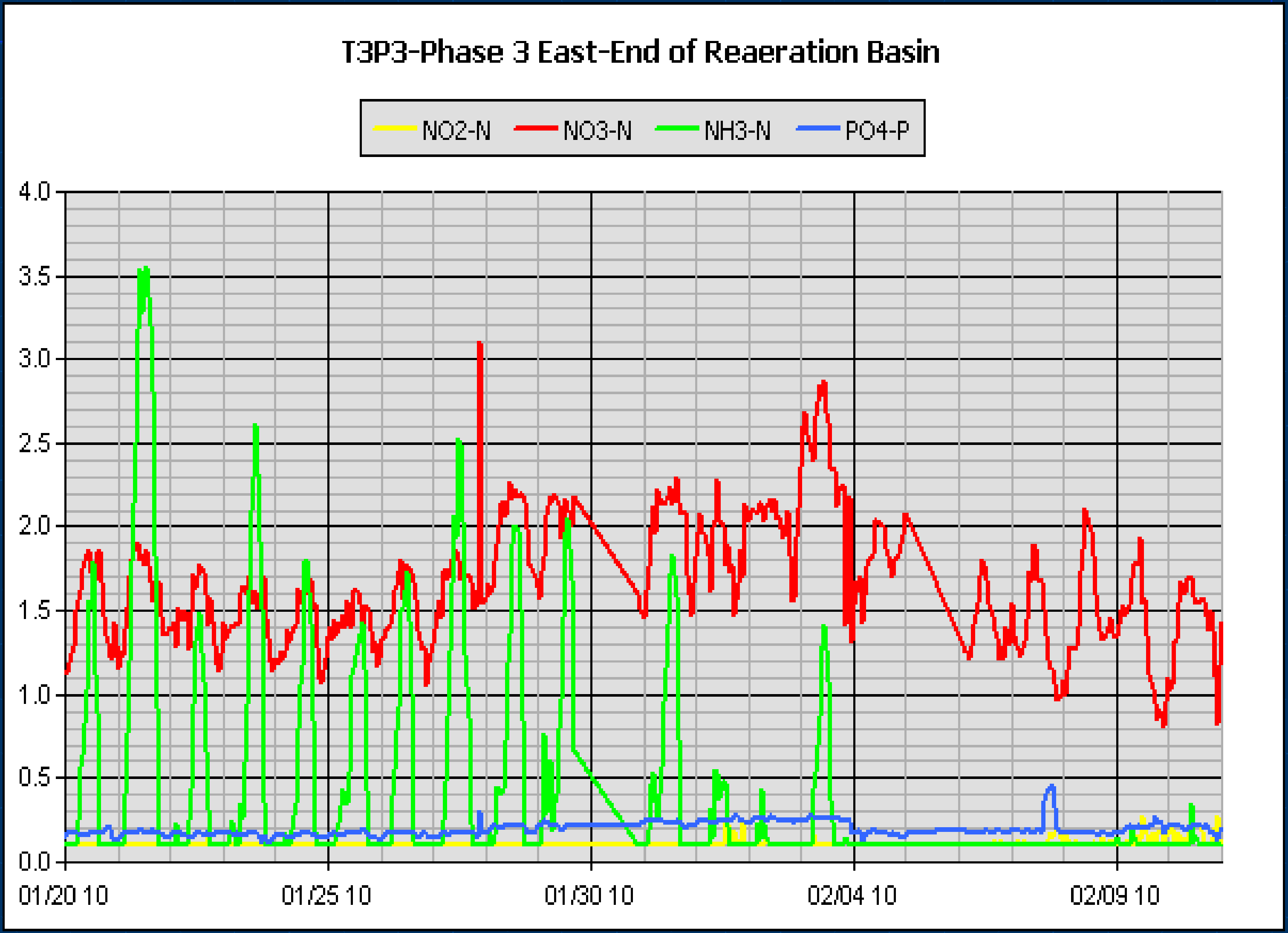
BardenPho Sample 2 Aeration Basin

- Mid Level NH3
- Mid Level NO3
- Low PO4
- Low NO2



BardenPho Sample 3 Aeration Basin

- Low NH3
- Low NO3
- Low PO4
- Low NO2



Benefits

- Rerate permit from 24 to 40 mgd – 4 pages of data, not theory, 3 pages of pictures
- Improved effluent quality – more flow with the same or less total pounds of nutrients
- >$30-70 million capital savings
- >$250k per month operating cost reduction
- 40% reduction in effluent nutrients
- 30+% reduction in solids production!

Summary

- Multiple parameters and sample points may require analysis to provide information to control nutrient removal processes
- Technology is available that can provide reliable automatic chemical analysis
- Selection of appropriate sample points and parameters for analysis is important
- When monitoring system is tied directly to aeration control, plants can produce better effluent, save operational expenses and delay expansion by rerating existing plant