Ammonia Controlled Aeration

CSWEA 85th Annual Conference

Brown AND Caldwell

Ammonia Controlled Aeration Goals

- Reduced energy consumption
- Reduced total nitrogen

Table 6: Overview of simulated and full-scale energy savings and improvements of total nitrogen removal

	WWTP Morgental 35,000 PE		WWTP Thunersee 130,000 PE		WWTP Werdhoelzli 600,000 PE
	simulation	full-scale	simulation	full-scale	simulation
Energy	-30%	-20%	-30%	-16.5%	-25%
TN removal	+48%	+40%	+60%	+40%	+32%

- Rieger, WEFTEC 2010

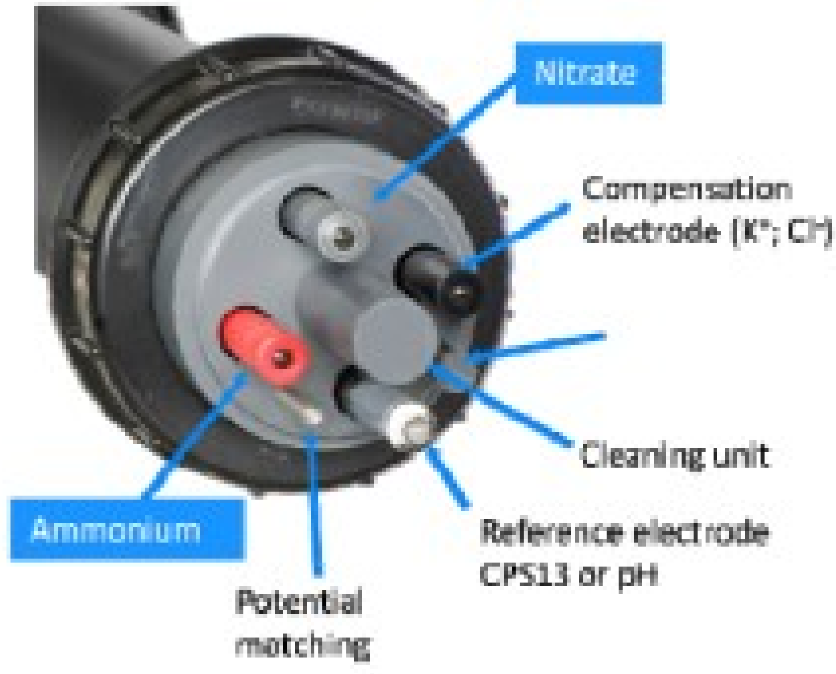
Outline

- Ammonia Sensor Studies
- Ammonia Aeration Control Strategies
- Case Studies
- Close

Ammonia/Nitrogen Sensors

WTW

Hach



Endress + Hauser

2007 WERF On-line Nitrogen Monitoring Study

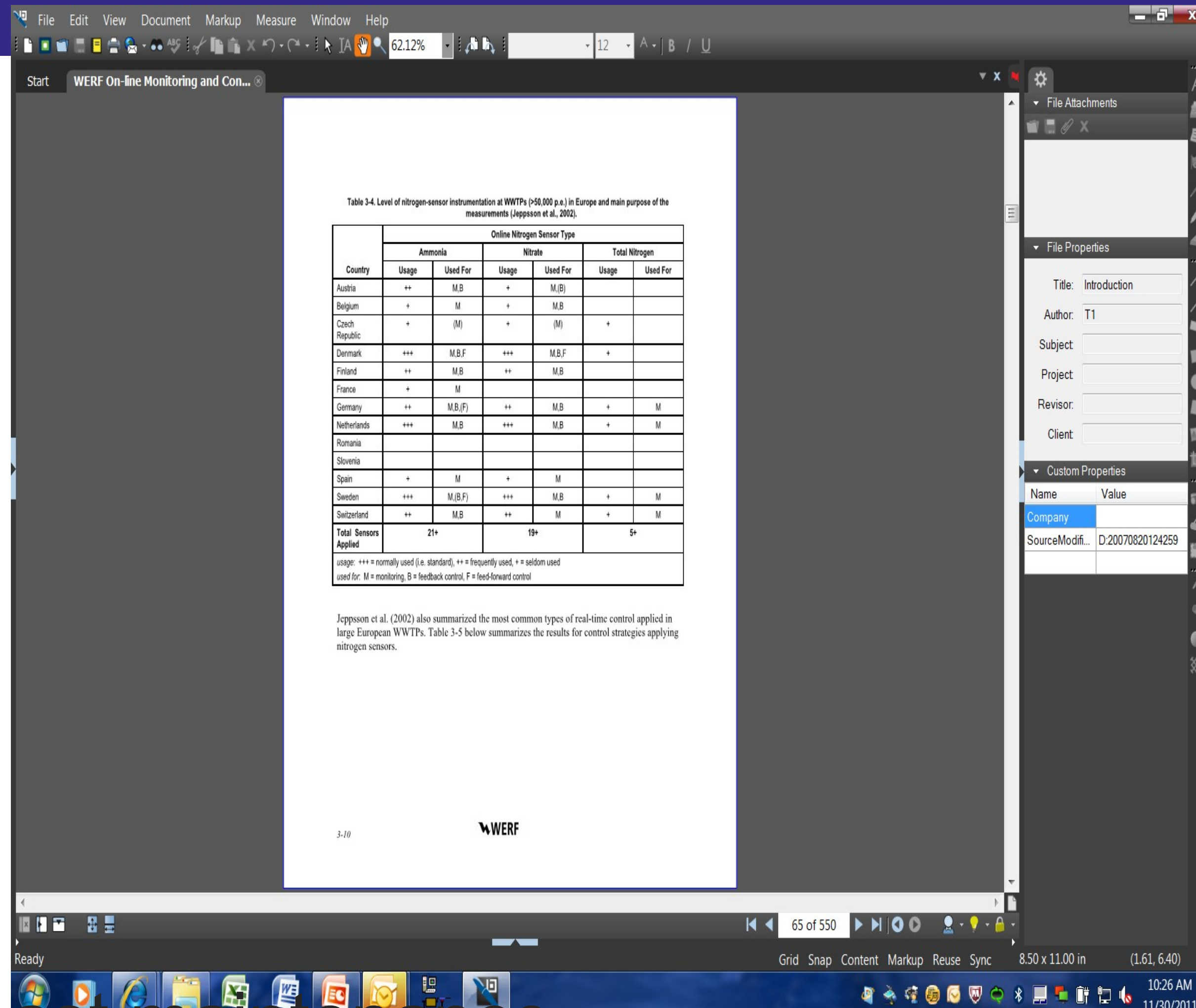


Table 3-4. Level of nitrogen-sensor instrumentation at WWTPs (>50,000 p.e.) in Europe and main purpose of the measurements (Jeppsson et al., 2002).

Country	Online Nitrogen Sensor Type					
	Ammonia		Nitrate		Total Nitrogen	
	Usage	Used For	Usage	Used For	Usage	Used For
Austria	++	M,B	+	M,(B)		
Belgium	+	M	+	M,B		
Czech Republic	+	(M)	+	(M)	+	
Denmark	+++	M,B,F	+++	M,B,F	+	
Finland	++	M,B	++	M,B		
France	+	M				
Germany	++	M,B,(F)	++	M,B	+	M
Netherlands	+++	M,B	+++	M,B	+	M
Romania						
Slovenia						
Spain	+	M	+	M		
Sweden	+++	M,(B,F)	+++	M,B	+	M
Switzerland	++	M,B	++	M	+	M
Total Sensors Applied	21+		19+		5+	

usage: +++ = normally used (i.e. standard), ++ = frequently used, + = seldom used
used for: M = monitoring, B = feedback control, F = feed-forward control

Jeppsson et al. (2002) also summarized the most common types of real-time control applied in large European WWTPs. Table 3-5 below summarizes the results for control strategies applying nitrogen sensors.

3-10 WERF

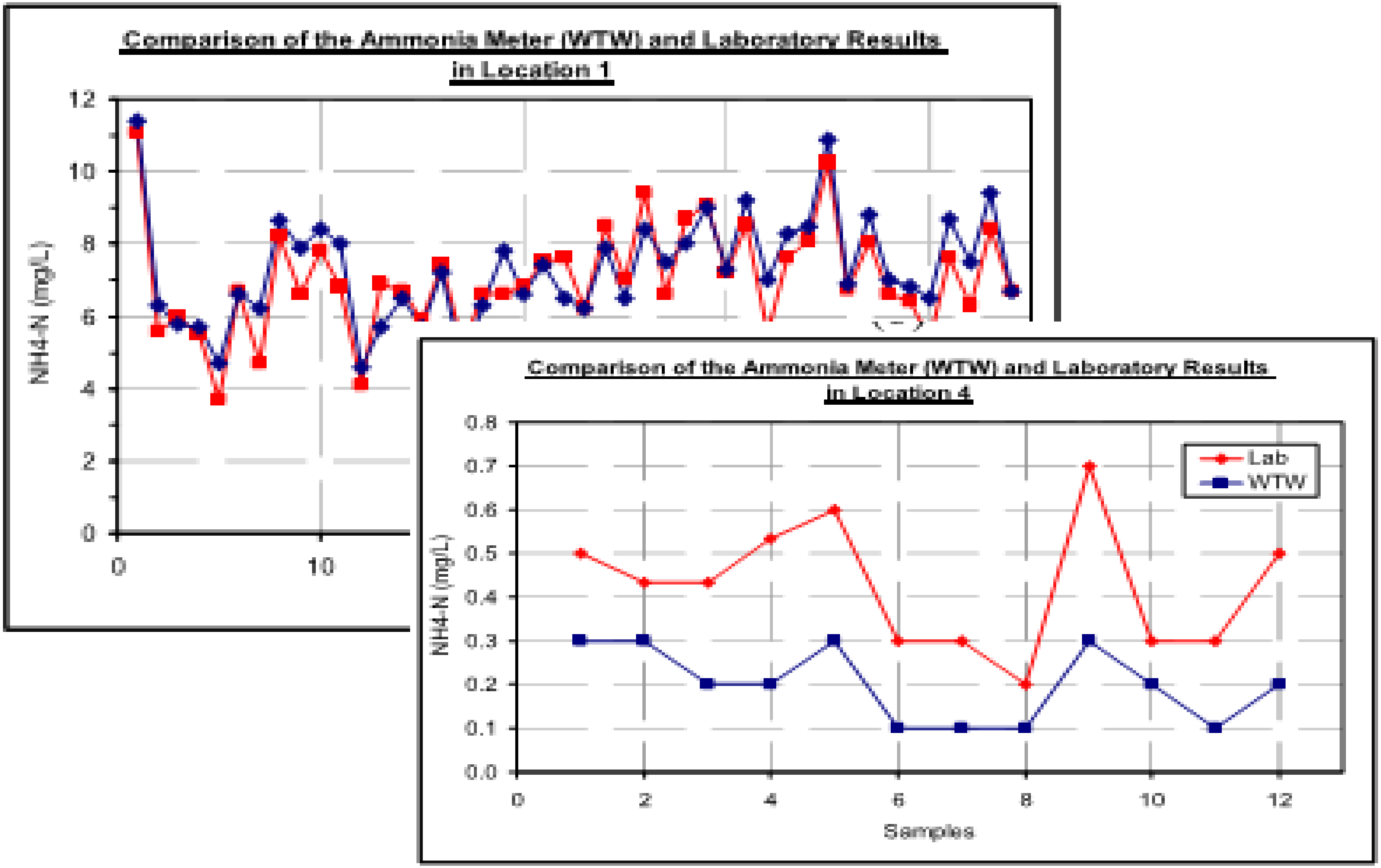
Nitrogen sensors

- Common in Europe for N control
- Less frequent use in U.S.

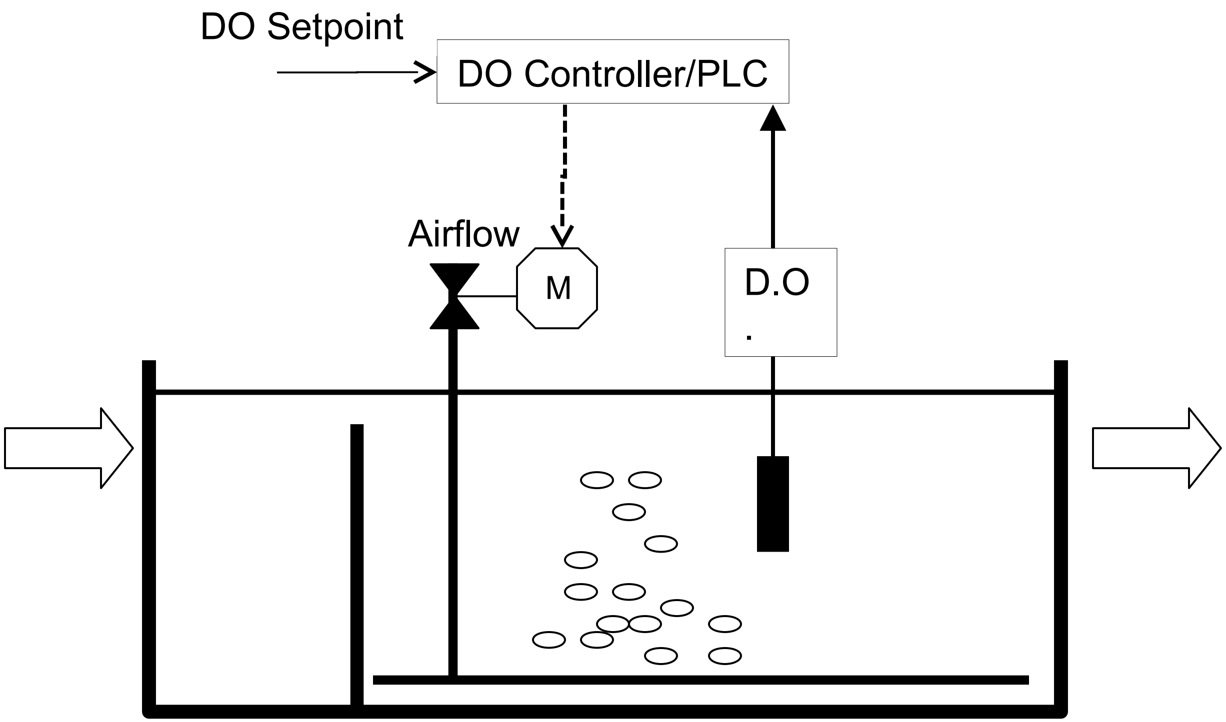
Lessons Learned

- 1 instrument type
- Most reliable with least maintenance
- Use at least one instrument/battery (train)

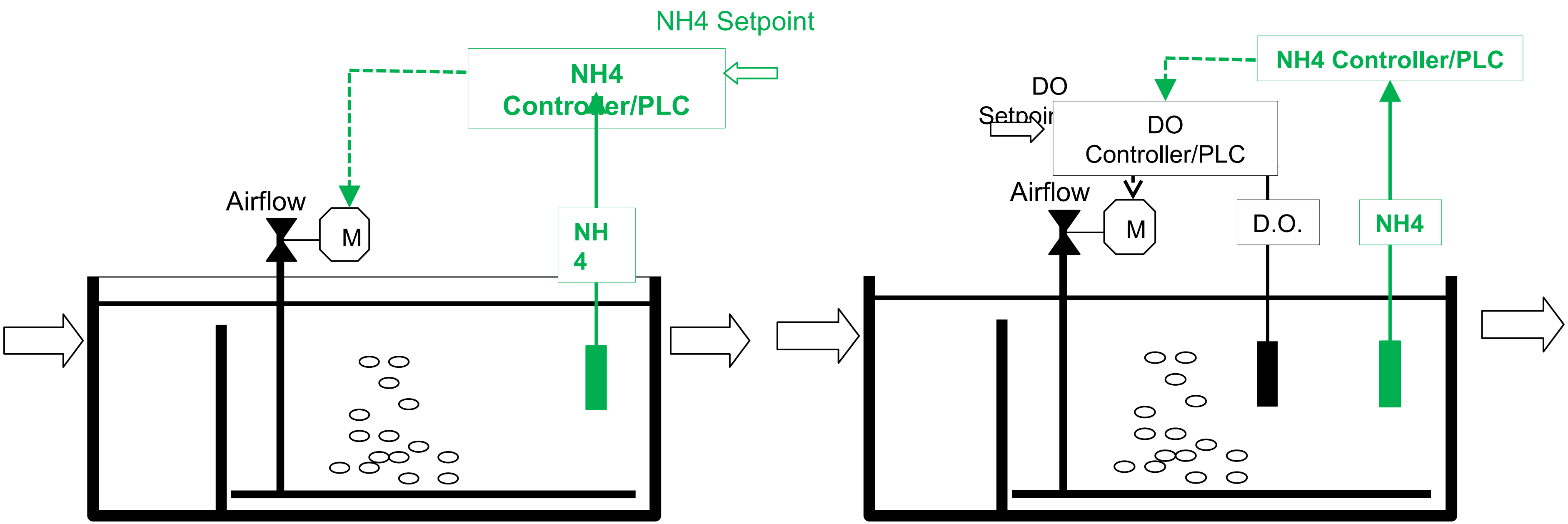
Santa Clara/San Jose Ammonia Sensor Evaluation



Typical Aeration Basin Control Strategy



Ammonia/Aeration Basin Control Strategies



Ammonia Control

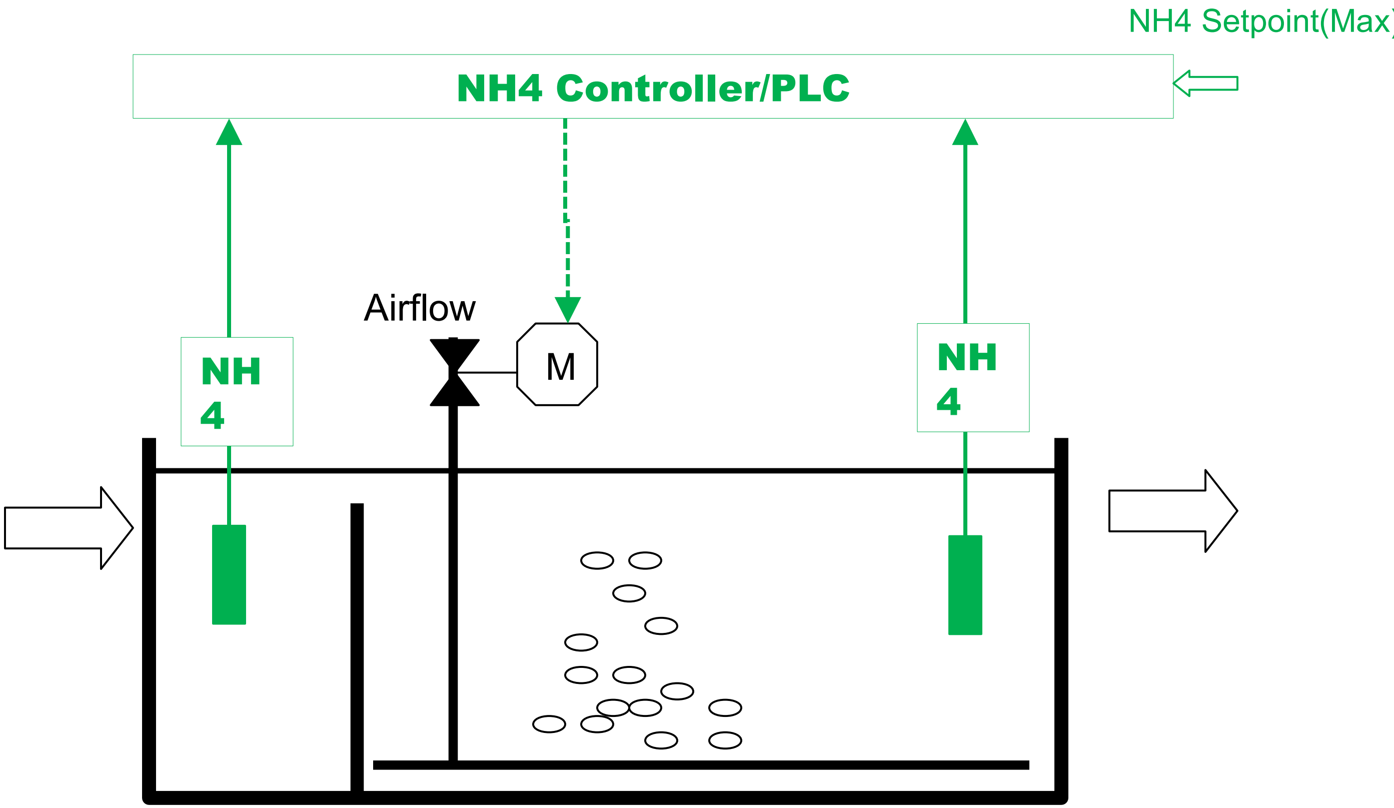
Cascade to DO set point

Example

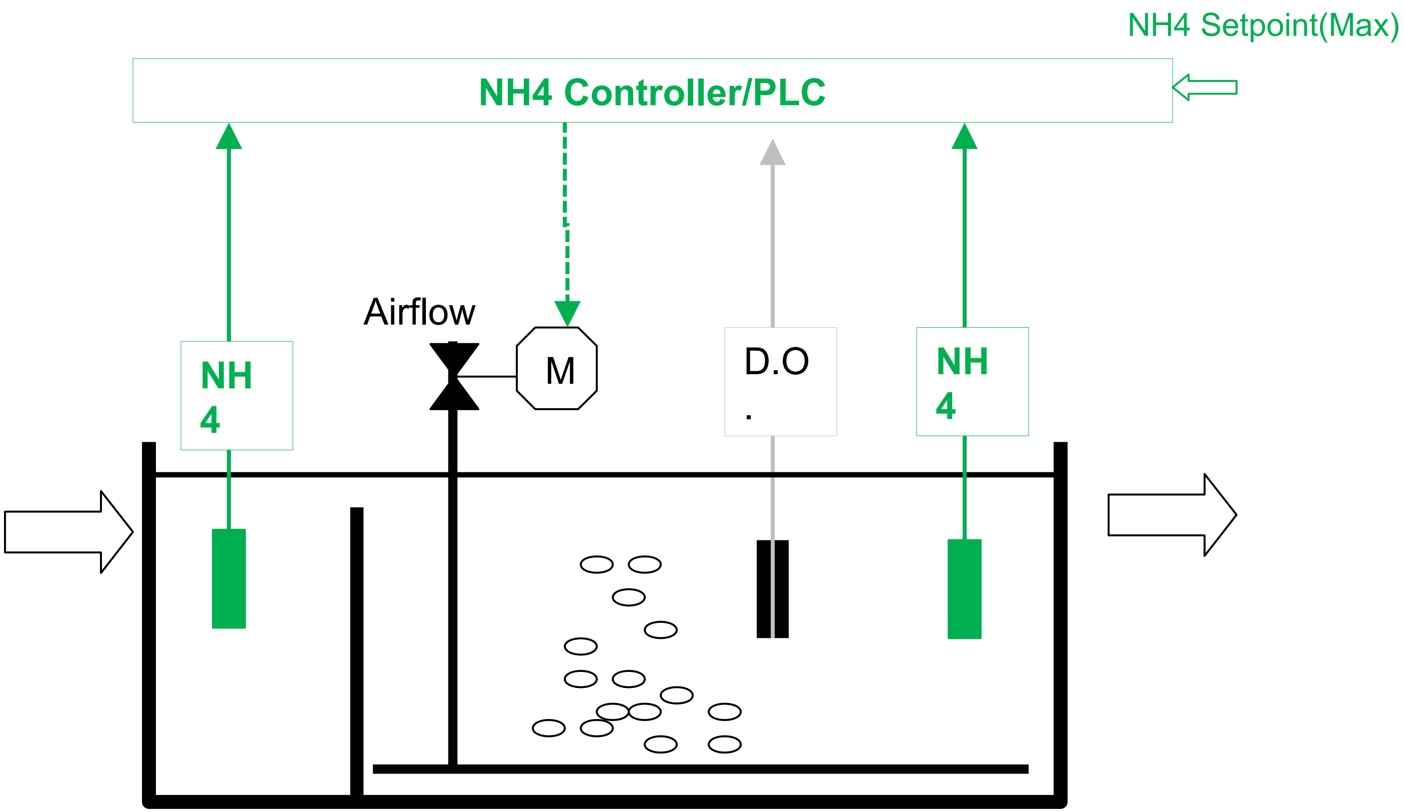
NH4 < 1.5 mg/L then DO setpoint = 0.5 mg/L

NH4 >1.6 mg/L then DO setpoint = 2.0 mg/L

Ammonia Feedback – Feed Forward Control

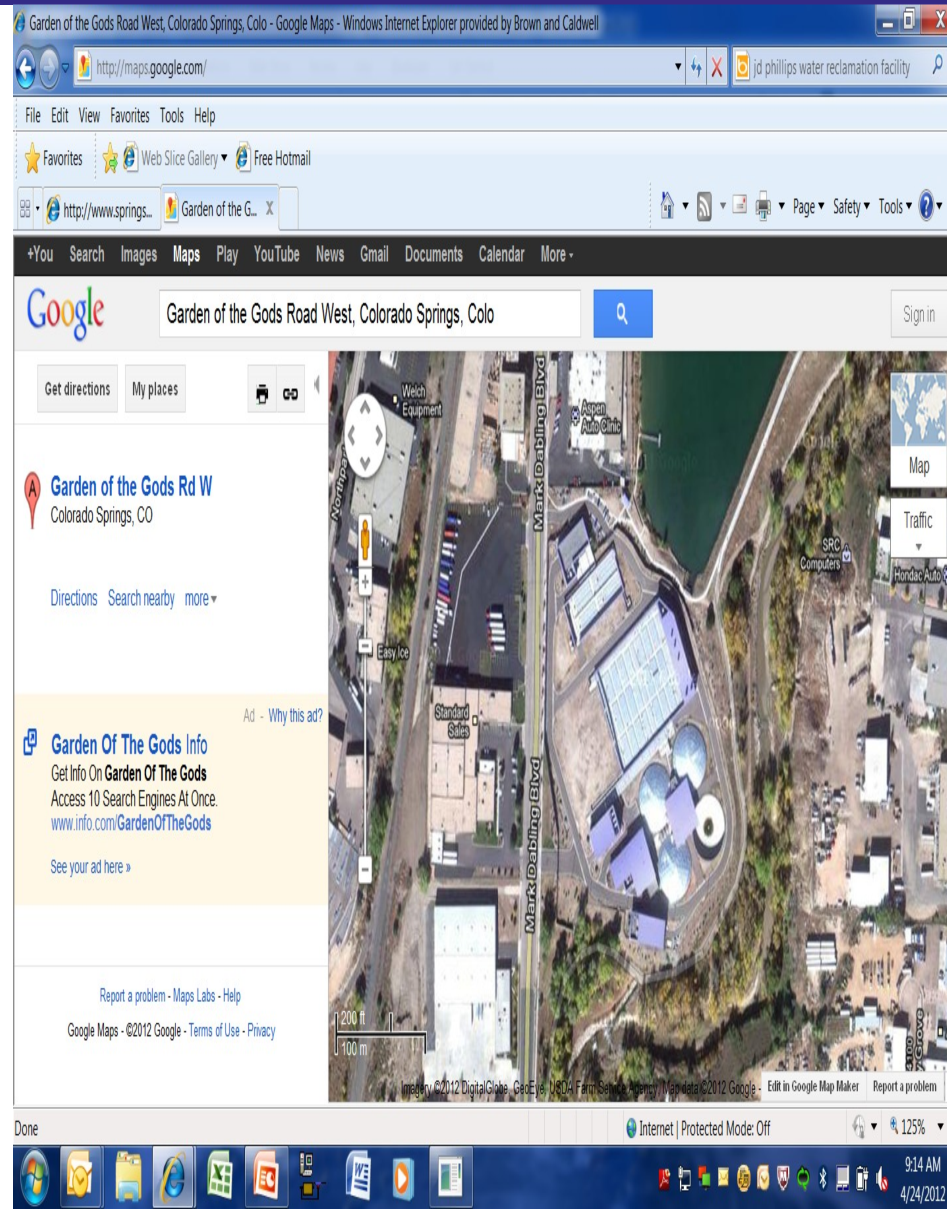


Ammonia Feedback – Feed Forward Control

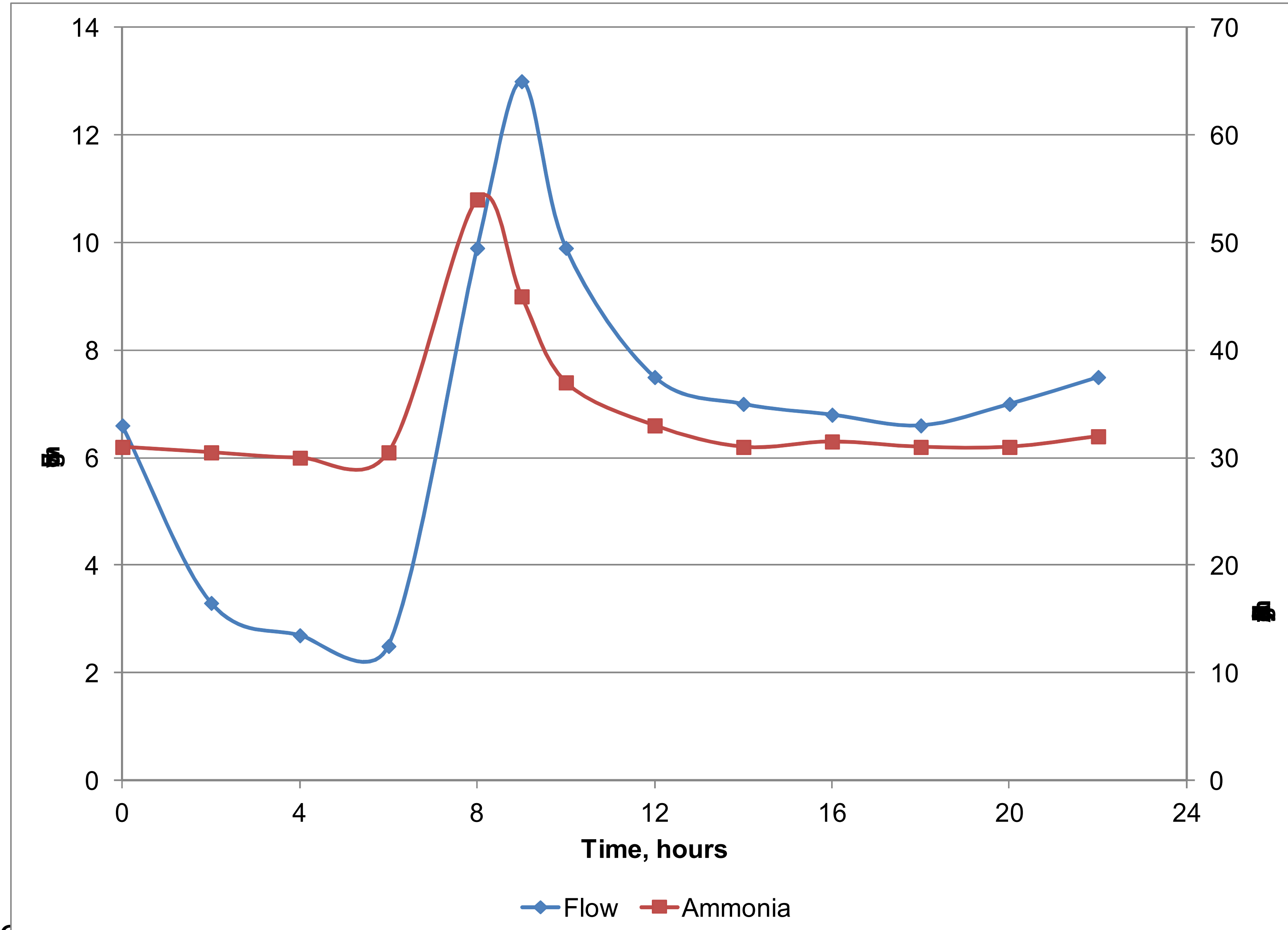


Case Example: J.D. Phillips WRF

- Flow: 8 mgd
- Design Capacity: 23.6 mgd MLE facility
- Blowers
  - Small/Large
- Permit
  - Ammonia
  - pH

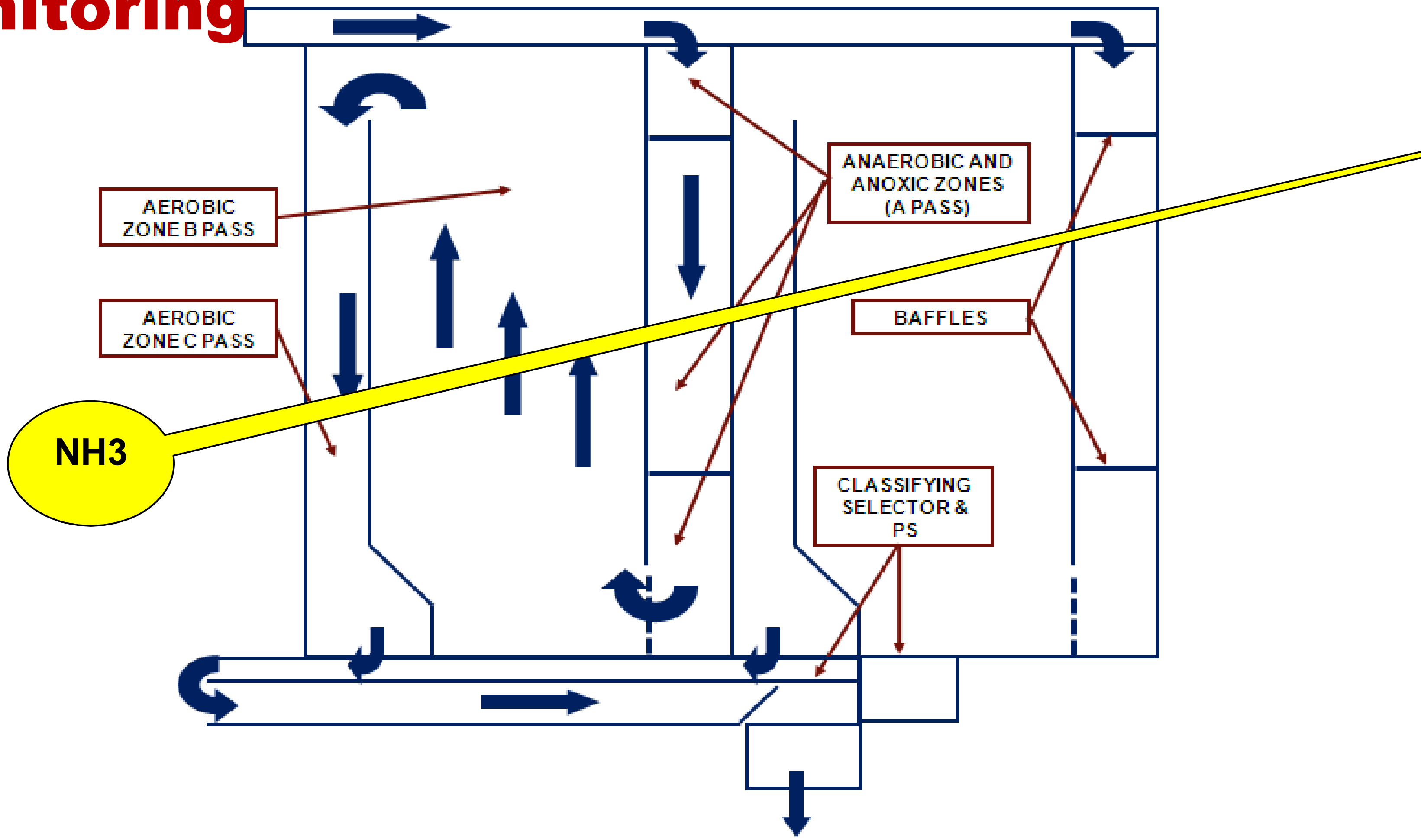


Case Example: J.D. Phillips WRF



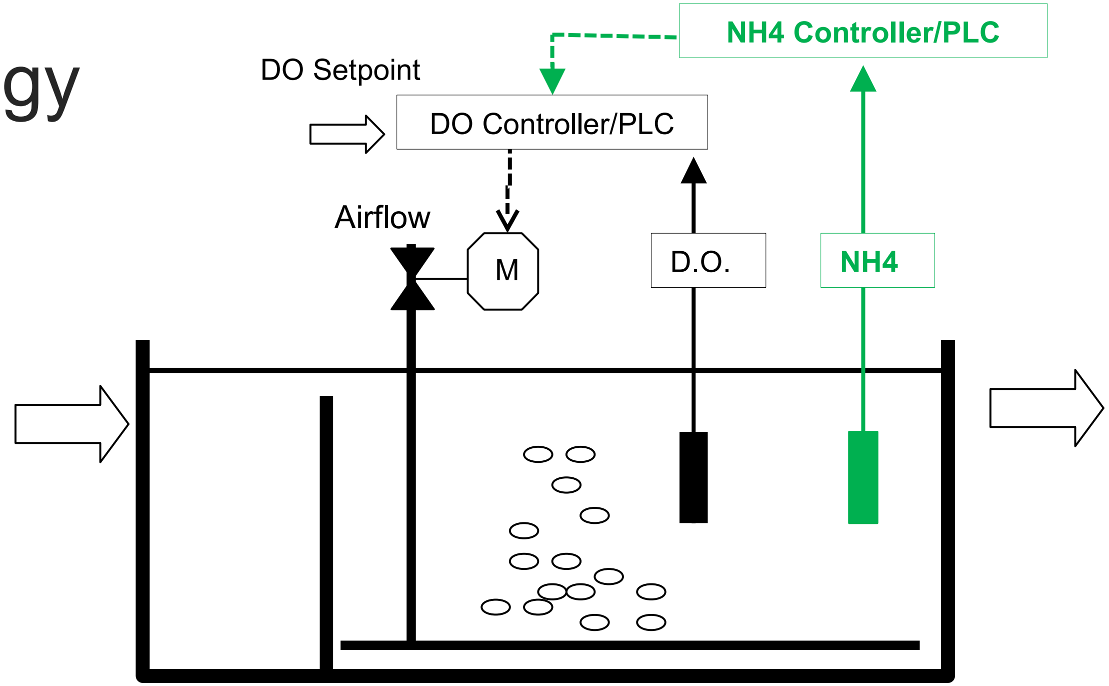
Case Example: J.D. Phillips WRF

- **Initial Driver: Monitoring**



Case Example: J.D. Phillips WRF

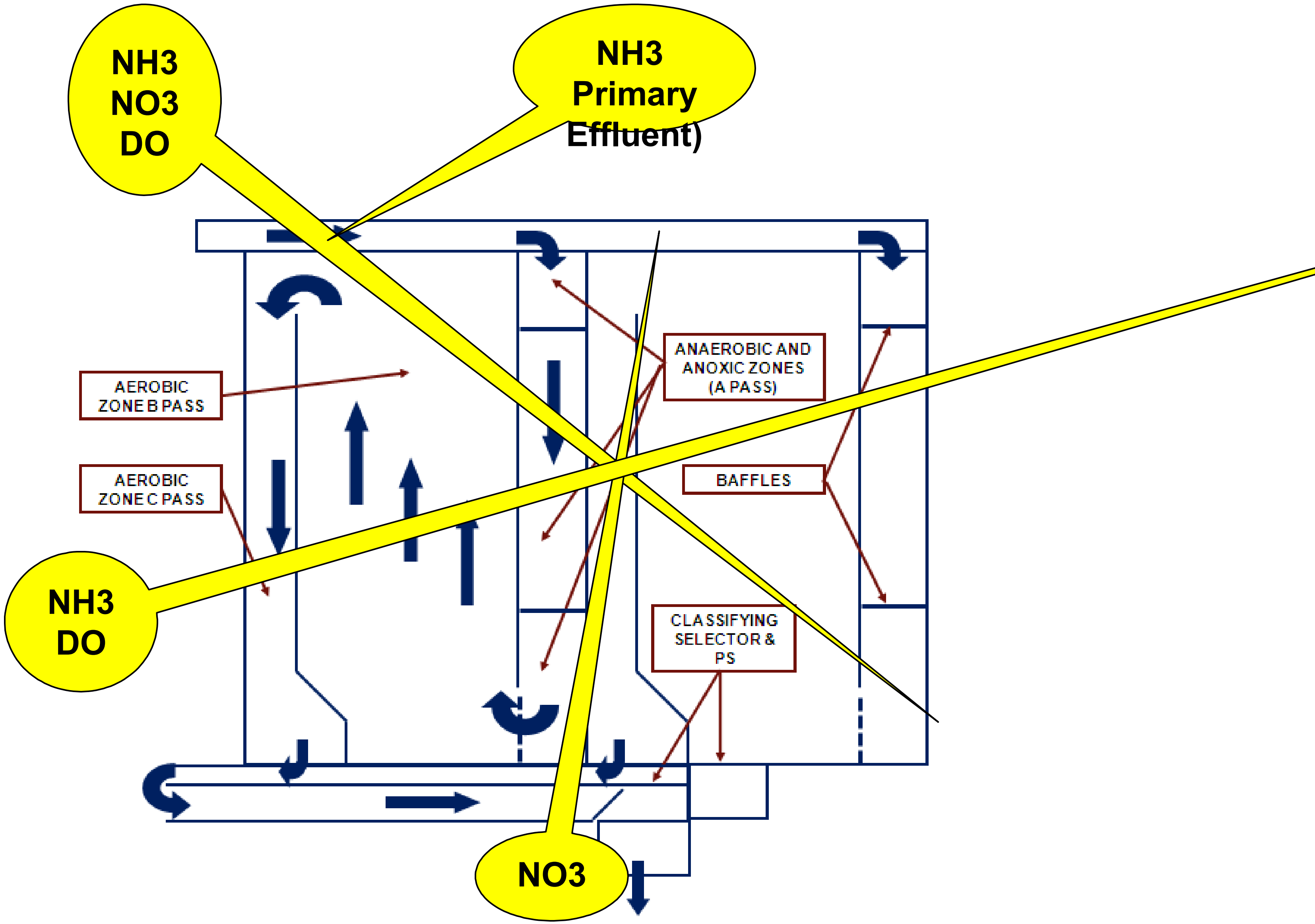
- Initial Control Strategy
  - Ammonia cascade loop w/DO control



<u>Findings</u>

- Biological response to ammonia “slug” was fast
- Control slow to adjust DO setpoint
- More complexity & difficult to control and tune

Case Example: J.D. Phillips WRF

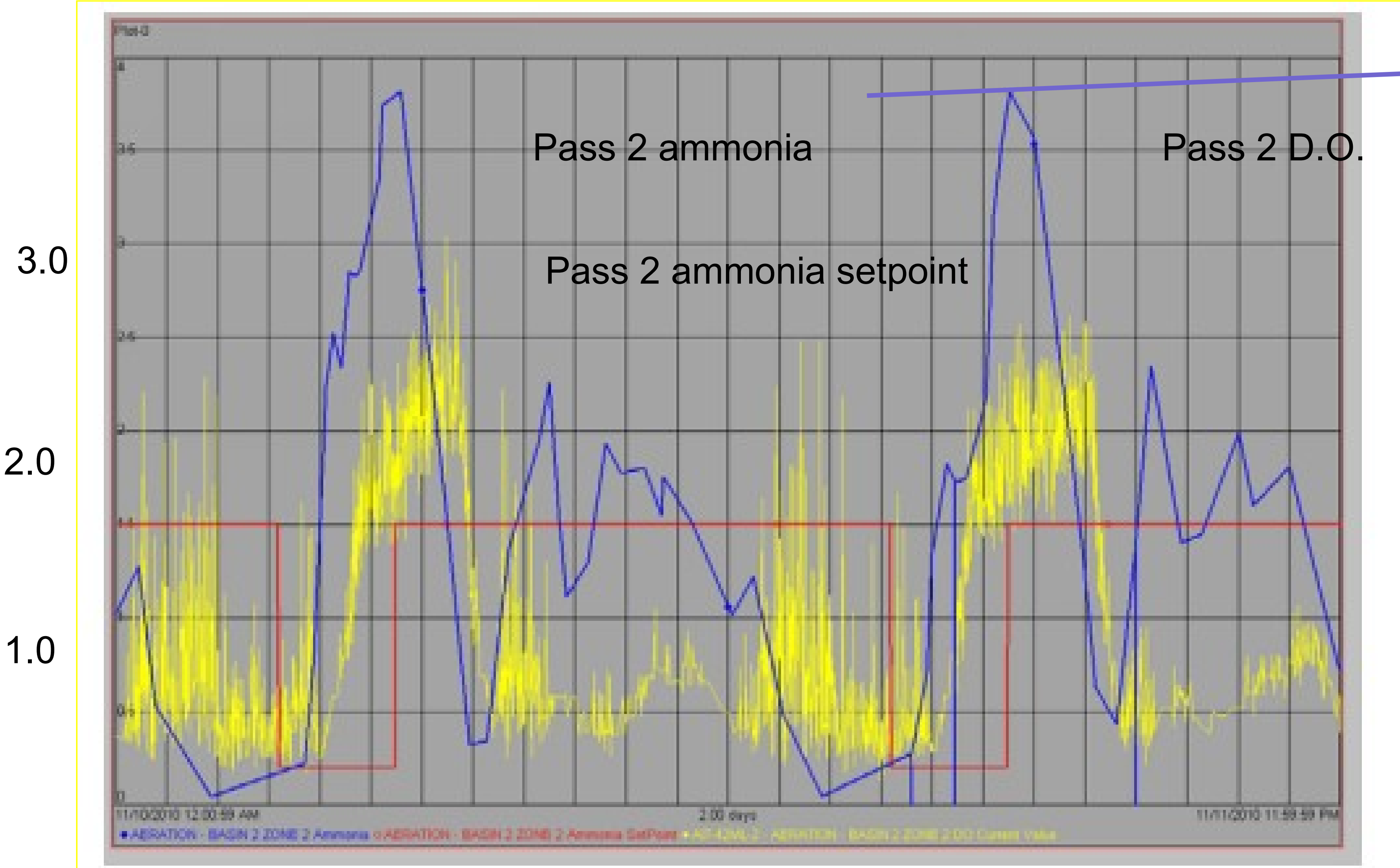


Case Example: J.D. Phillips WRF

- Base Aeration Control Strategy

Item	Value	Comments
Pass B - Ammonia Control		
Effluent NH4 Target	1.5 mg /L	Operator input
Pass B Middle Setpoint	3 mg/L 0.2 mg/L (am only)	Algorithm from Historical trends
Pass C	Check on Pass B 90% NH3-N removed	
Pass 2 – DO Control		
Target D.O	0.5 – 3.5 mg /L	Filament control
Pass 3 – DO Control		
Target D.O	0.5 mg /L	Prevent denitrification in secondary clarifiers

Case Example: J.D. Phillips WRF



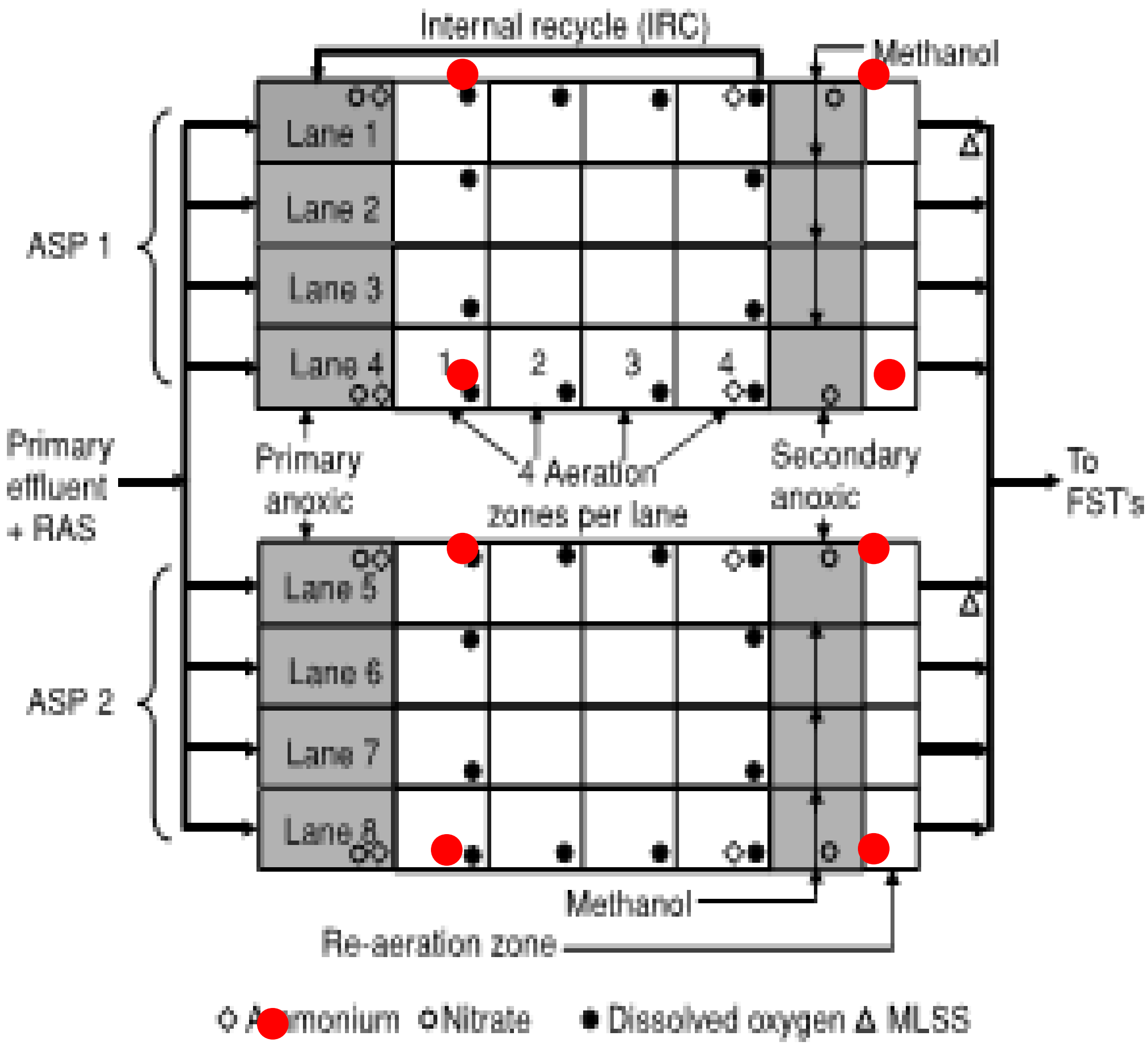
Source: WEFTEC 2010

Case Example: J.D. Phillips WRF

Lessons Learned

- Sensors are reliable with proper maintenance
  - Calibrate ≈ monthly
  - 1 -2 hours/calibration/probe (recommend Hach kits)
  - Replace sensor caps every 6 months
- Algorithm takes time to develop and change
- 20-30% energy savings
  - Save during off-peaks
  - Blower turndown essential
- Beneficial for plant nitrifier upsets
- PE can be difficult application – head of basin for feed forward control

Case Example 2 – U.K. 4-Stage Bardenpho



<u>Optimized DO</u>

Zone 1 = 2.0 mg/L

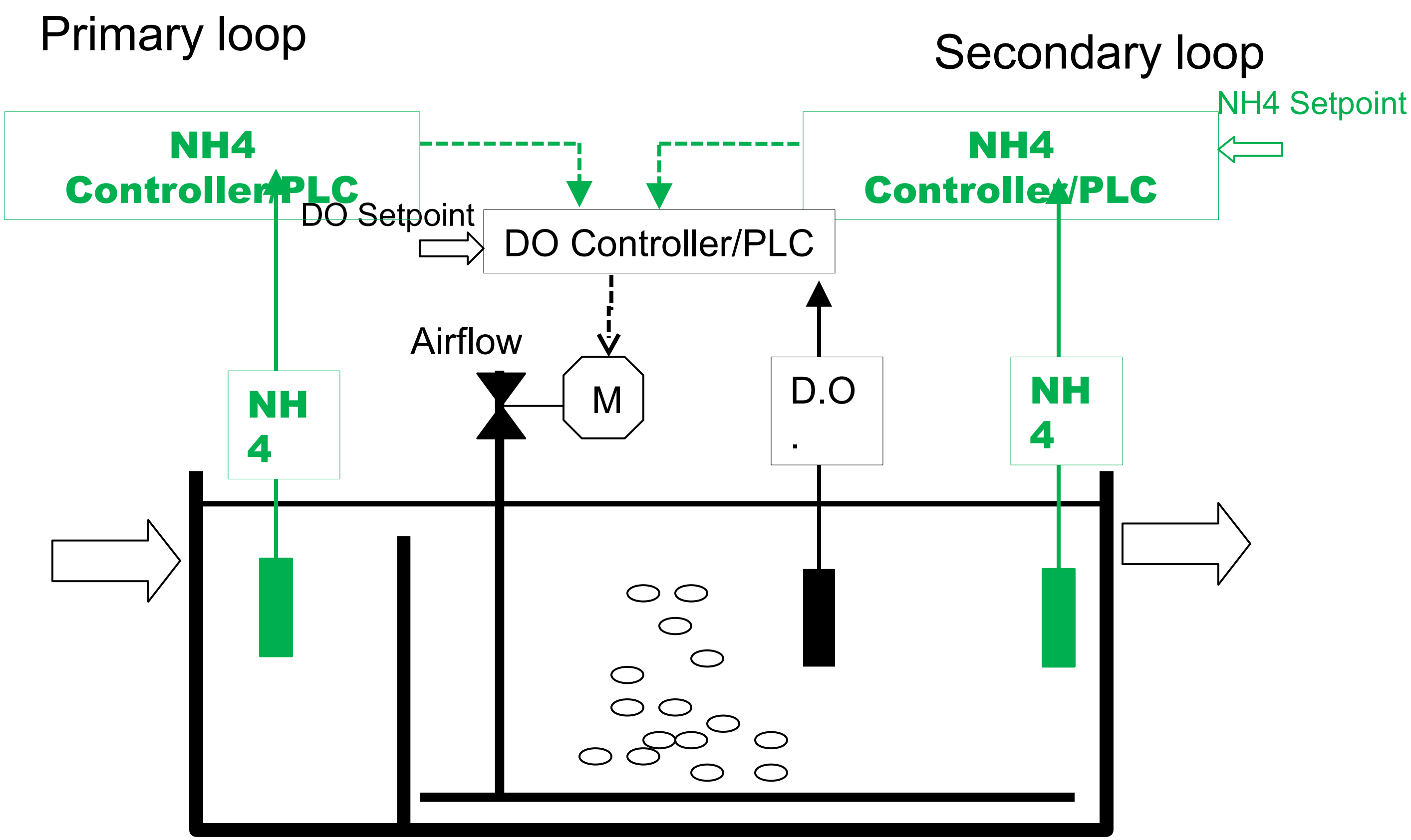
Zone 2 = 2.1 mg/L

Zone 3 = 1.6 mg/L

Zone 4 = 0.5 mg/L

Source: WST, 61.9,2010

Case Example 2 – Aerated Zone Control



Aerated Zone DO setpoints based upon Feed-Forward anoxic zone ammonia using process model correlations

Case Example 2 – U.K. 4-Stage Bardenpho

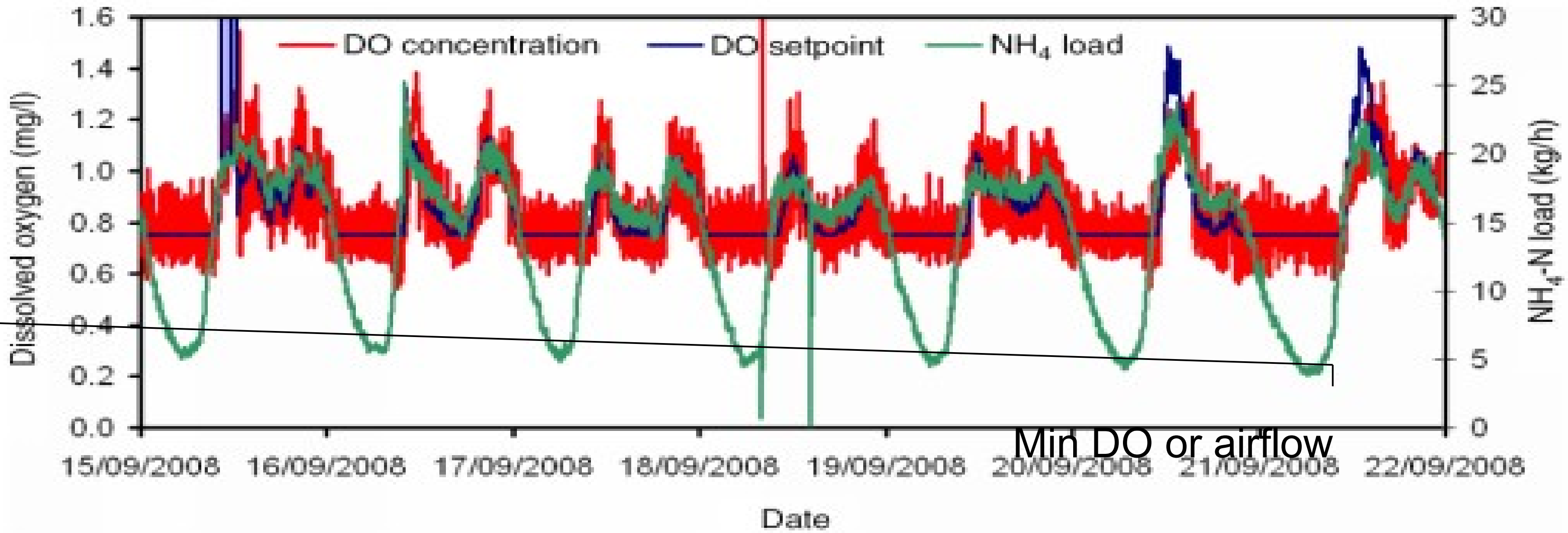


Figure 2 | Lane 1 load and lane 1, zone 1 DO/DO setpoint characteristics.

Source: WST, 61.9,2010

Case Example 2 – U.K. 4-Stage Bardenpho

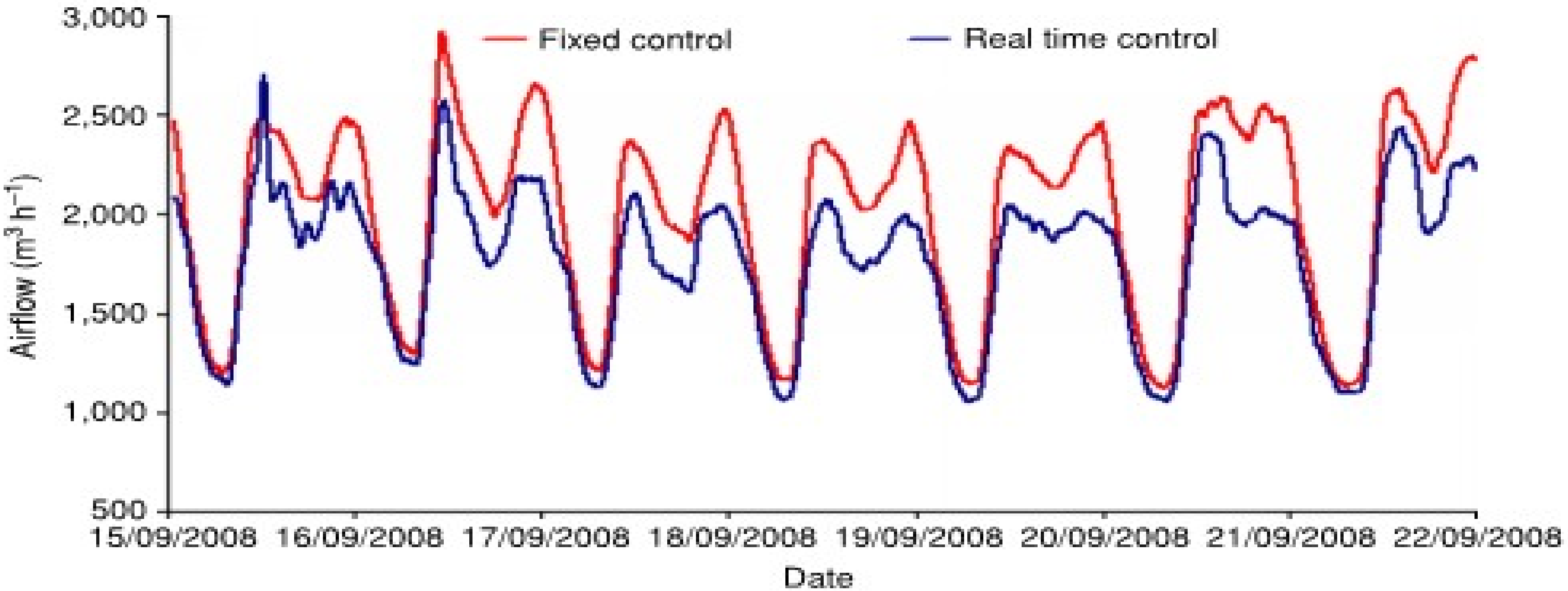
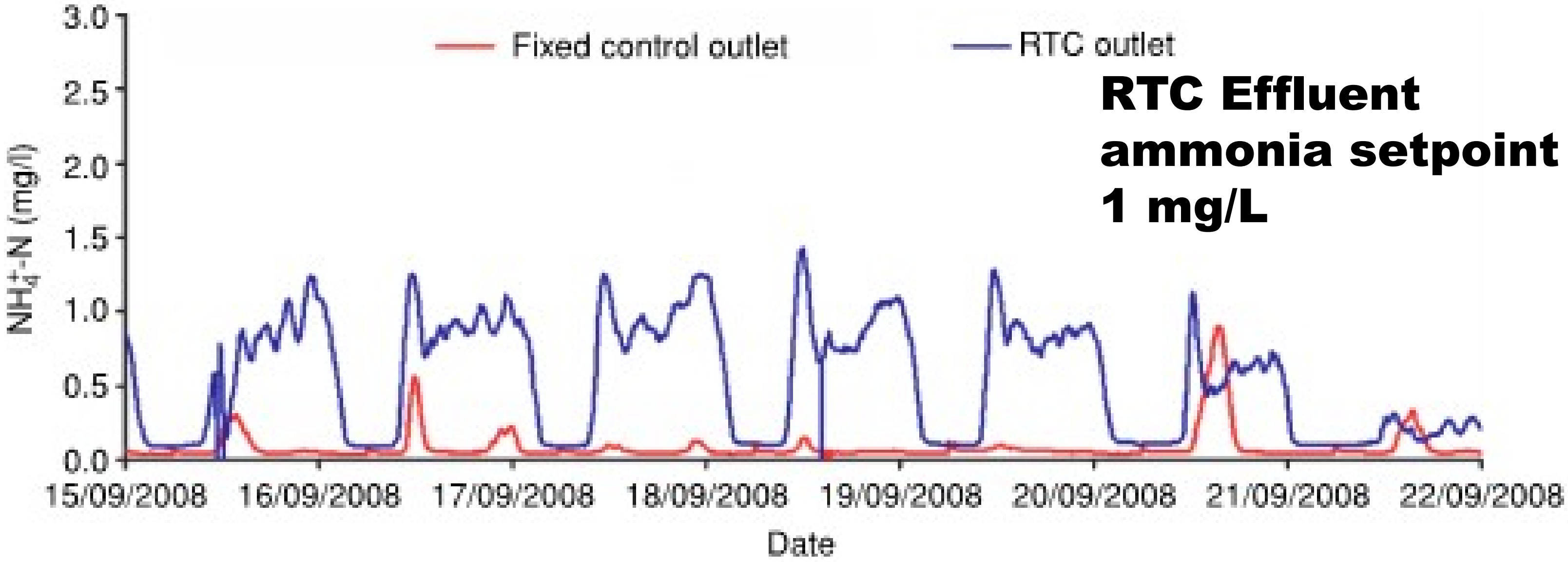


Figure 3 | Airflows for aeration zone 1 of master lanes 1 and 8.

20% airflow savings overall

Source: WST, 61.9,2010

Case Example 2 – U.K. 4-Stage Bardenpho



RTC Effluent ammonia setpoint of 1 mg/L

Source: WST, 61.9,2010

Ammonia Aeration Control - General

Need reliable and accurate sensors – test sensors for requirements

Advanced Aeration control can be more complex

- Sensor outlay and maintenance
- More monitoring
- More maintenance (0.5 to 3 hours/week/device)
- Cascade loops – lag times/fine tuning
- Historical treatment or process model algorithms
- Feed-forward provides greater safety w.r.t peak loadings

Low D.O. bulking a concern – especially if the initial zone D.O. <2.0 mg/L for a nitrifying activated sludge system (higher for non-nitrifying systems)

Acknowledgements

- Jay Hardison and Bill Hoyt, City of Colorado Springs

Questions