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WATER TECHNOLOGIES

Get A Ph.D In pH Shift Odor Control

TRANSFORMING WATER. ENRICHING LIFE.

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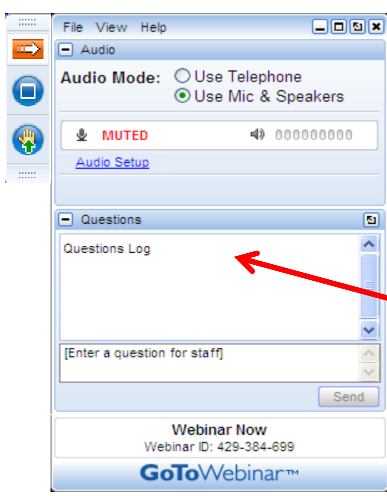
How to Participate Today



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- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

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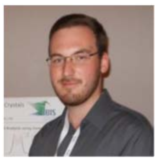
Your Presenters Today Are:

- Calvin Horst, Product Manager, Odor Control



- Justin Stewart, Application Engineer, Odor Control

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pH Shift Odor Control - Outline

- **Wastewater Odors**
  - What are they and where do they come from
- **pH Shift Odor Control**
  - Methodology
  - Products – Characteristics / Pros / Cons
- **Case Study**
  - Method
  - Results

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Odorous Compounds

Substance	Formula	Characteristic Odor	Odor Threshold (ppm)
Allyl Mercaptan	CH_2=CH-CH_2-SH	Strong garlic-coffee	0.00005
Amyl Mercaptan	CH_3-$(CH_2)_3$-CH_2-SH	Unpleasant-putrid	0.0003
Benzyl Mercaptan	$C_6H_5CH_2$-SH	Unpleasant-strong	0.0002
Crotyl Mercaptan	CH_3-CH=CH-CH_2-SH	Skunk-like	0.00003
Dimethyl Sulfide	CH_3-S-CH_3	Decayed vegetables	0.0001
Ethyl Mercaptan	CH_3CH_2-SH	Decayed cabbage	0.0002
Hydrogen Sulfide	H_2S	Rotten Eggs	0.0005
Methyl Mercaptan	CH_3SH	Decayed cabbage	0.0011
Propyl Mercaptan	CH_3-CH_2-CH_2-SH	Unpleasant	0.000075
Sulfur Dioxide	SO_2	Pungent, irritating	0.009
Tert-Butyl Mercaptan	$(CH_3)_3$C-SH	Skunk, unpleasant	0.00008
Thiocresol	CH_3-C_6H_4-SH	Skunk, rancid	0.00006
Thiophenol	C_6H_5SH	Putrid, garlic like	0.00006
Amines	CH_3NH_2, $(CH_3)_3N$	Fishy	0.035, 0.000032
Ammonia	NH_3	Ammoniacal	1.5
Diamines (cadaverine)	$NH_2(CH_2)_nNH_2$	Decayed Flesh	-
Skatole	$C_8H_5NHCH_3$	Fecal	0.0000056

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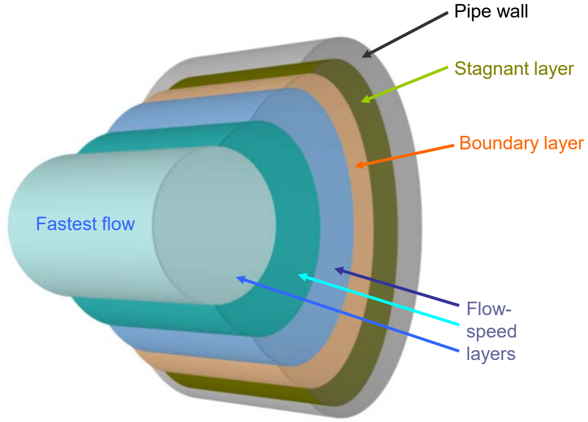
Hydrogen Sulfide – Generation – Mechanism

- When any liquid flows through a pipe, the fastest flow speed is at the center of the pipe.
- Toward the pipe wall, liquid flows in concentric, progressively slower, flow-speed layers.
- The slowest flow-speed layer, called the boundary layer, is next to a stagnant (no-flow) layer at the pipe wall.



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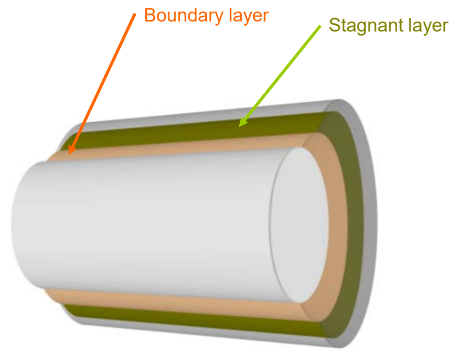
Hydrogen Sulfide – Generation – Mechanism

- Natural-occurring bacteria grow in the stagnant layer and feed on the sewage that migrates through the boundary layer.



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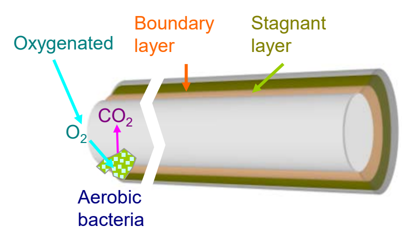
Hydrogen Sulfide – Generation – Mechanism

- The type of bacteria depends on the availability of oxygen:
  - In an oxygenated environment, the bacteria are aerobic; they "breathe" oxygen (O_2) and release carbon dioxide (CO_2).



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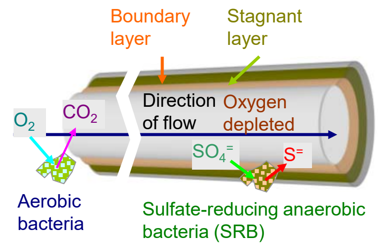
Hydrogen Sulfide – Generation – Mechanism

- In long sewage pipes, oxygen consumption by aerobic bacteria in the upstream segment creates an oxygen-depleted zone in the downstream segment, in which anaerobic bacteria thrive.



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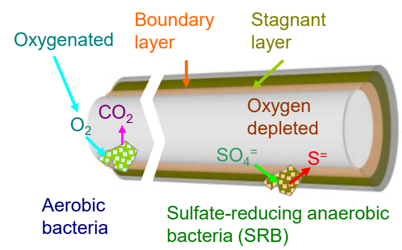
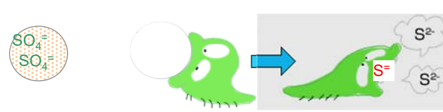
Hydrogen Sulfide – Generation – Mechanism

- The type of bacteria depends on the availability of oxygen:
  - Anaerobic sulfate-reducing bacteria (SRB) form in an oxygen-depleted environment.
  - In such an environment, SRB "inhale" sulfate ($SO_4^=$) and "exhale" sulfide ($S^=$).





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Sulfide – pH Ionization relationship

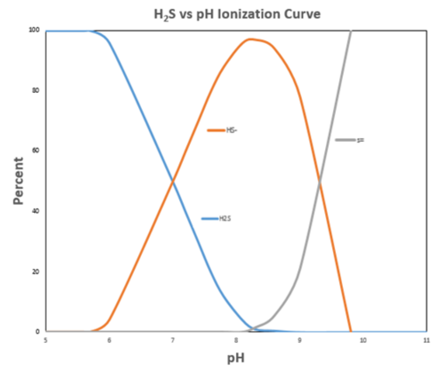
Sulfide in solution exists in 1 of 3 forms:

- Dissolved hydrogen sulfide gas (H_2S)
- Bisulfide (HS^-)
- Sulfide ($S^=$)

Of these 3 H2S is volatile and can be liberated through turbulence.

The prevailing form depends on pH.

As pH increases, H_2S shifts to one of the two non-volatile ionic forms.



- $S^=$: non-volatile
- HS^- : non-volatile
- H_2S : volatile, can off-gas to cause corrosion and odors.

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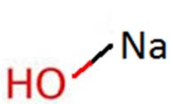
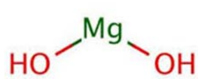
pH SHIFT PRODUCT OPTIONS



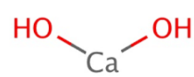
Characteristics

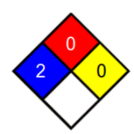
- Solubility 109 g/L
- Does not self buffer
- Does not contribute to the formation of Struvite
- Highly Corrosive
- High/Serious Health Hazard



Characteristics

- Non-Hazardous
- Self Buffering
- Self Buffering to 8.5
- Slurry can accumulate if overfed
- Difficult to monitor for overfeed
- Contributes to the formation of Struvite





Characteristics

- Wide pH range\controllable
- Dissolves rapidly
- Doesn't form Struvite
- Slurry can accumulate if overfed
- Can cause scaling if overfed

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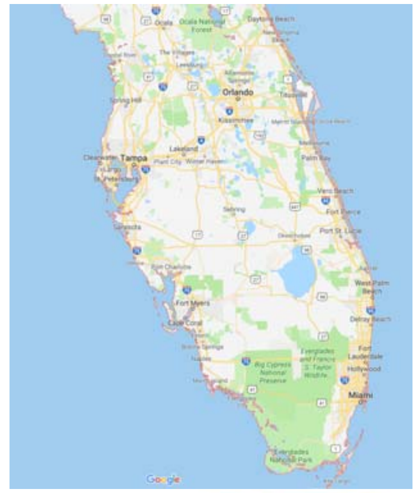
Case Study – Wastewater Treatment Plant – Southern Florida



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Case Study – Wastewater Treatment Plant – Southern Florida

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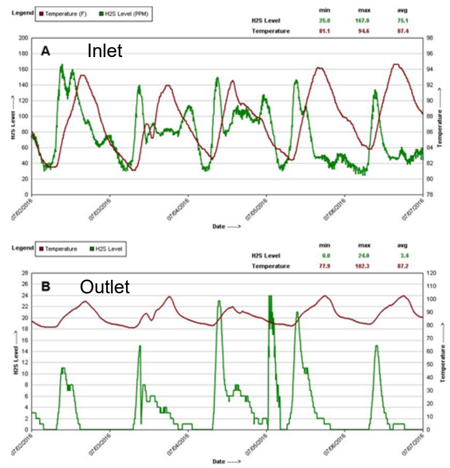
Case Study – Scrubber Performance

- This WWTP is located in a high profile tourist district.
- Complaints were received regarding "rotten egg" odors around the plant.
- Headworks covers and EQ tank was confirmed to be airtight. Scrubber was air-balanced.
- Odor complaints persisted. Scrubber was unable to completely remove H_2S.



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Case Study - Wastewater Treatment Plant – Southern Florida

- Plant scheduled to be decommissioned and converted to a Master Pump Station by 2018.
- Needed a temporary solution for controlling H_2S odors from the scrubber effluent.
- Solution should be:
  - Not cost – prohibitive or capital intensive
  - Mobilized quickly / provide immediate results
- Liquid phase odor control via. temporary feed system deemed most economical solution.

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Methods – Technology Evaluation

- <u>Design Considerations / Limitations:</u>
  - Upstream lift stations lack physical space for installation of chemical feed systems.
  - Upstream lift stations are located in sensitive tourist or residential areas.
  - Feed system must be able to control odors by feeding chemical at the WWTP.
  - Chemical safety is a concern / non hazardous chemicals preferred.

Upstream Lift Station	Flow (ML/d)	Length (m)	Size (cm)	Avg. RT (hrs)
Lift Station #1	0.999	604.4	15.2	0.3
Lift Station #2	0.625	430.7	15.2	0.3
Lift Station #3	1.110	976.6	20.3	0.7
Lift Station #4	0.814	958.6	15.2	0.5
Lift Station #5	0.625	430.7	15.2	0.3
Lift Station #6	0.386	1003.1	15.2	1.1
Average				0.5

- <u>Nitrate Salts: Calcium Nitrate Solution</u>
  - 1.5 hour RT for complete removal
  - Requires feed system upstream in collection system
- <u>Iron Salts: Ferric / Ferrous Sulfate Solutions</u>
  - ~ 5 minutes RT for complete reaction
  - Chemical safety is a concern
- <u>Oxidizers: Hydrogen Peroxide Solution</u>
  - ~ 30 minutes RT for complete removal
  - Chemical safety is a concern
- <u>pH Shift: Calcium / Magnesium Hydroxide</u>
  - $Ca(OH)_2$ dissolves rapidly
  - $Mg(OH)_2$ requires > 30 minutes to completely dissolve

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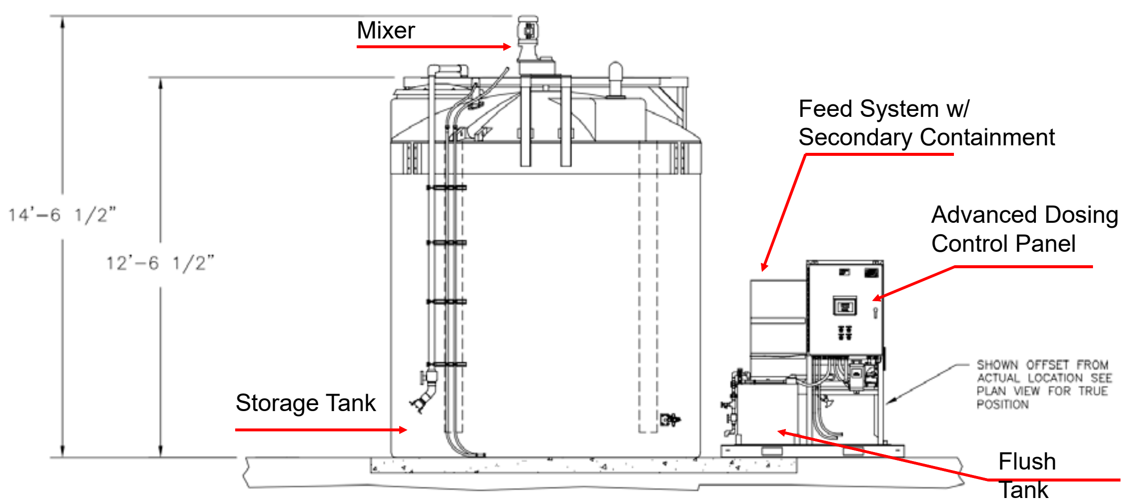
Methods – Chemical Feed Equipment



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Methods – Chemical Feed Equipment

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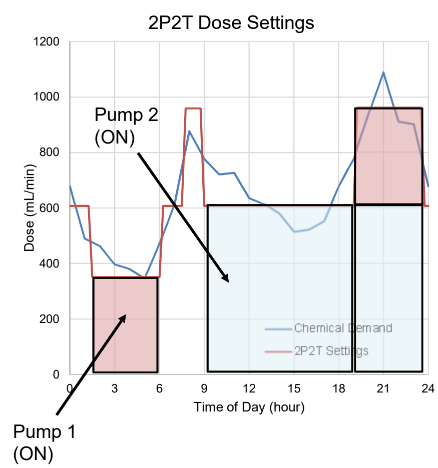
Dose Curve vs. Two Pump Two Timer

- Two Pump Two Timer (2P2T) systems attempt to satisfy changing chemical demand by using three set feed rates:
  - Only Pump 1 On
  - Only Pump 2 On
  - Both Pump 1 and Pump 2 On
- Many parts of the day are either overfed or underfed.
- Requires overshooting feed rates in order to achieve 100% sulfide control.
- "Best Fit" 2P2T settings to meet the daily Chemical demand



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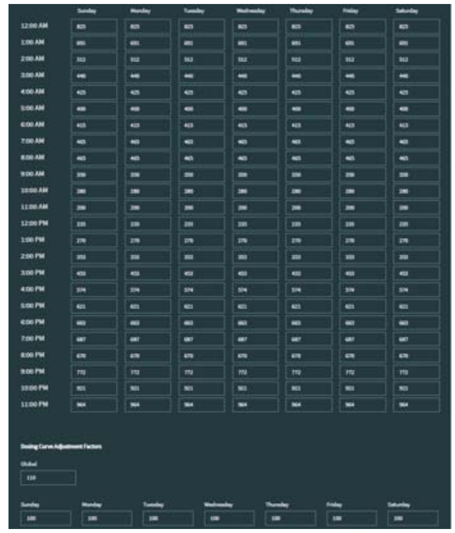
Advanced Dosing / Remote Monitoring



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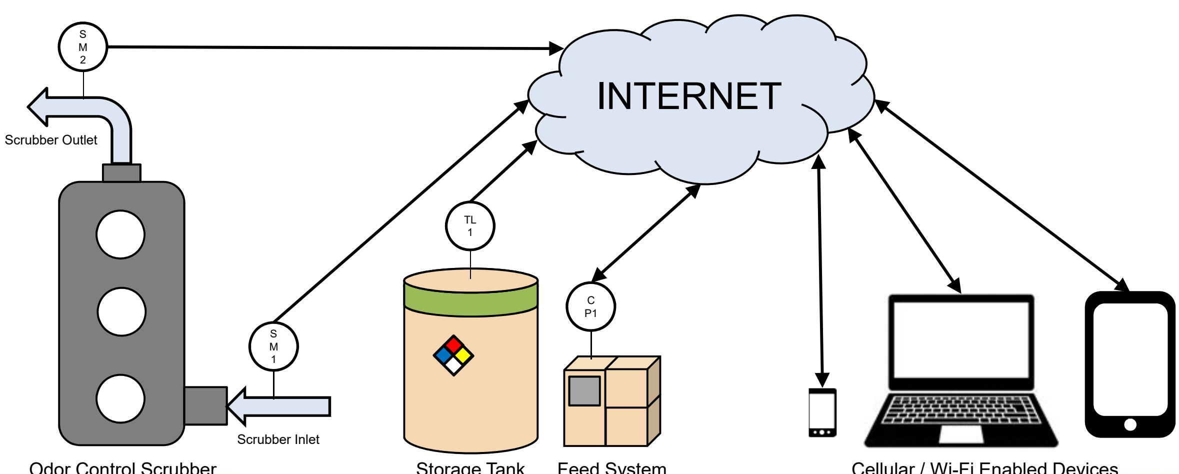
Advanced Dosing / Remote Monitoring



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Treatment Objective

- Plant ADF: 4.9 ML/d (1.3 MGD)
- Untreated Conditions:
  - Average Atmospheric H_2S (Inlet): 75 ppm_v
  - Average Atmospheric H_2S (Outlet): 3.4 ppm_v
  - Average Wastewater pH (headworks): 7.4
- Treatment Objective:
  - Average Atmospheric H_2S (Inlet): ≤ 10 ppm_v
  - Average Atmospheric H_2S (Outlet): ≤ 0.5 ppm_v
  - Average Wastewater pH (headworks): 8.3 – 8.5

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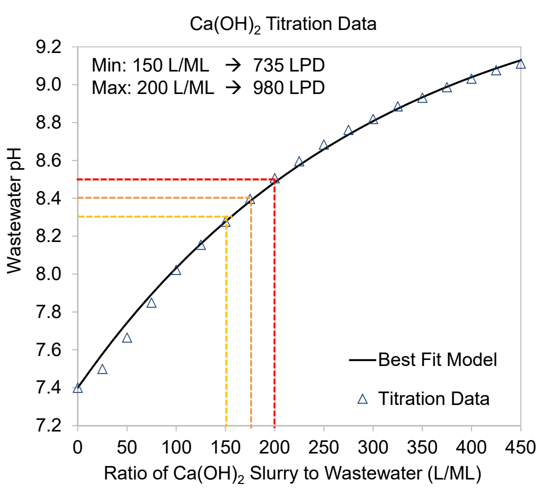
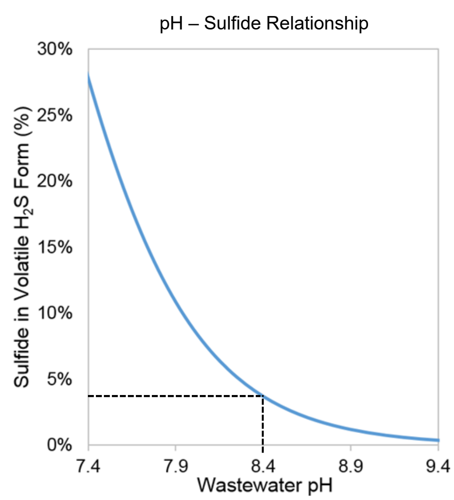
Treatment Objective – Dose Estimation





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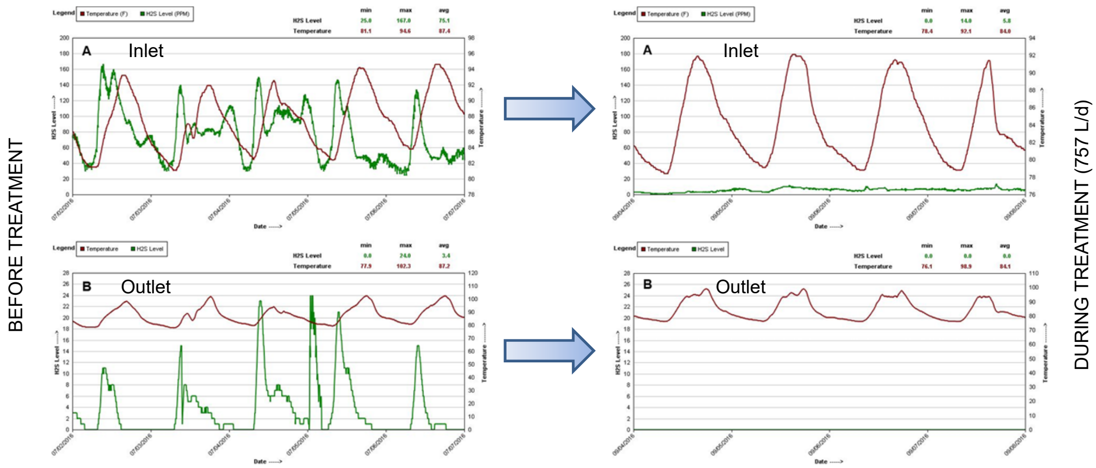
Results – Hydrogen Sulfide Concentrations



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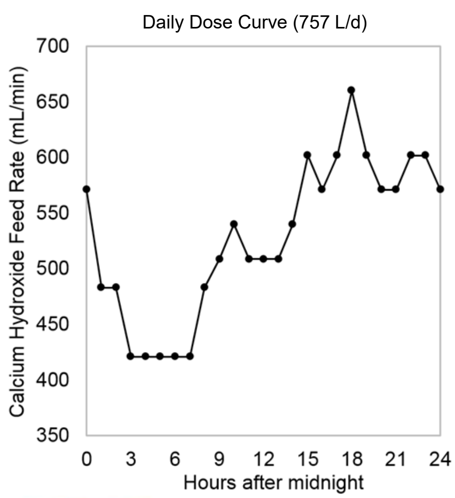
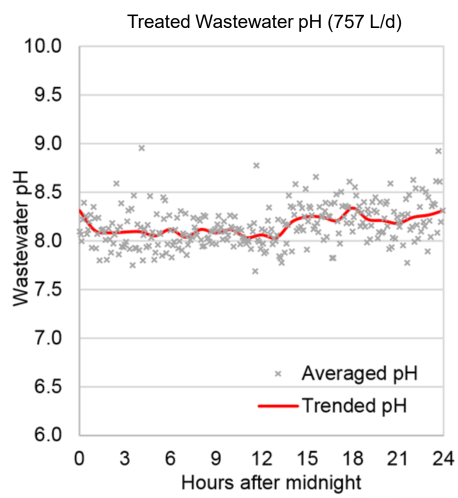
Results – Final Dose Curve / Treated pH





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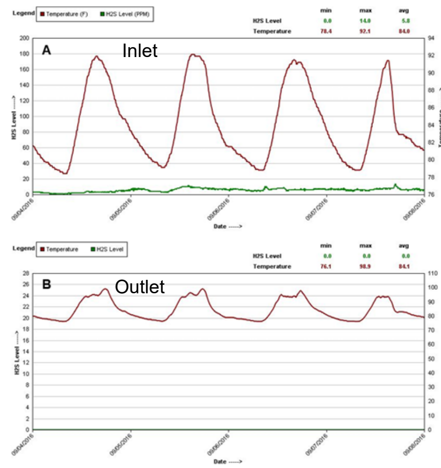
Results - Summary

- Plant ADF: 4.9 ML/d (1.3 MGD)
- Treatment Objective:
  - Predicted Daily Feed Rate: **735 - 980 L/d (195 - 260 GPD)**
  - Average Atmospheric H_2S (Inlet): **≤ 10 ppm$_v$**
  - Average Atmospheric H_2S (Outlet): **≤ 0.5 ppm$_v$**
  - Average Wastewater pH (headworks): **8.3 – 8.5**
- Results:
  - Actual Daily Feed Rate: **757 L/d (200 GPD)**
  - Average Atmospheric H_2S (Inlet): **5.8 ppm$_v$**
  - Average Atmospheric H_2S (Outlet): **0 ppm$_v$**
  - Average Wastewater pH (headworks): **8.2**



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Discussion / Conclusions

- By using a Calcium Hydroxide slurry, the Southern Florida WWTP was able to reduce H_2S loadings.
- H_2S levels were reduced such that the plants aging scrubber was able to handle any residual odors.
- Calcium Hydroxide slurry could be applied directly into WWTP influent flow at the plant headworks.
- Rapid dissolution of Calcium Hydroxide allowed for an instantaneous reduction of odors.
- Average pH was elevated from 7.4 to approximately 8.2 by feeding 757 L/d (200 GPD)
- Final optimized feed rates were actually less than what was originally predicted from initial titration / model data.
- Following this successful demonstration, the customer continued to treat the WWTP using Calcium Hydroxide.

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Text: Arial 18 or smaller, depending on amount of content.

Do not cover the footer or logo and wave with text.

Callouts: Arial 20 (if possible), bold, italicized; white font on blue background. Callout box should be no wider than text box on the page.

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