Overcoming Wastewater Odor Issues

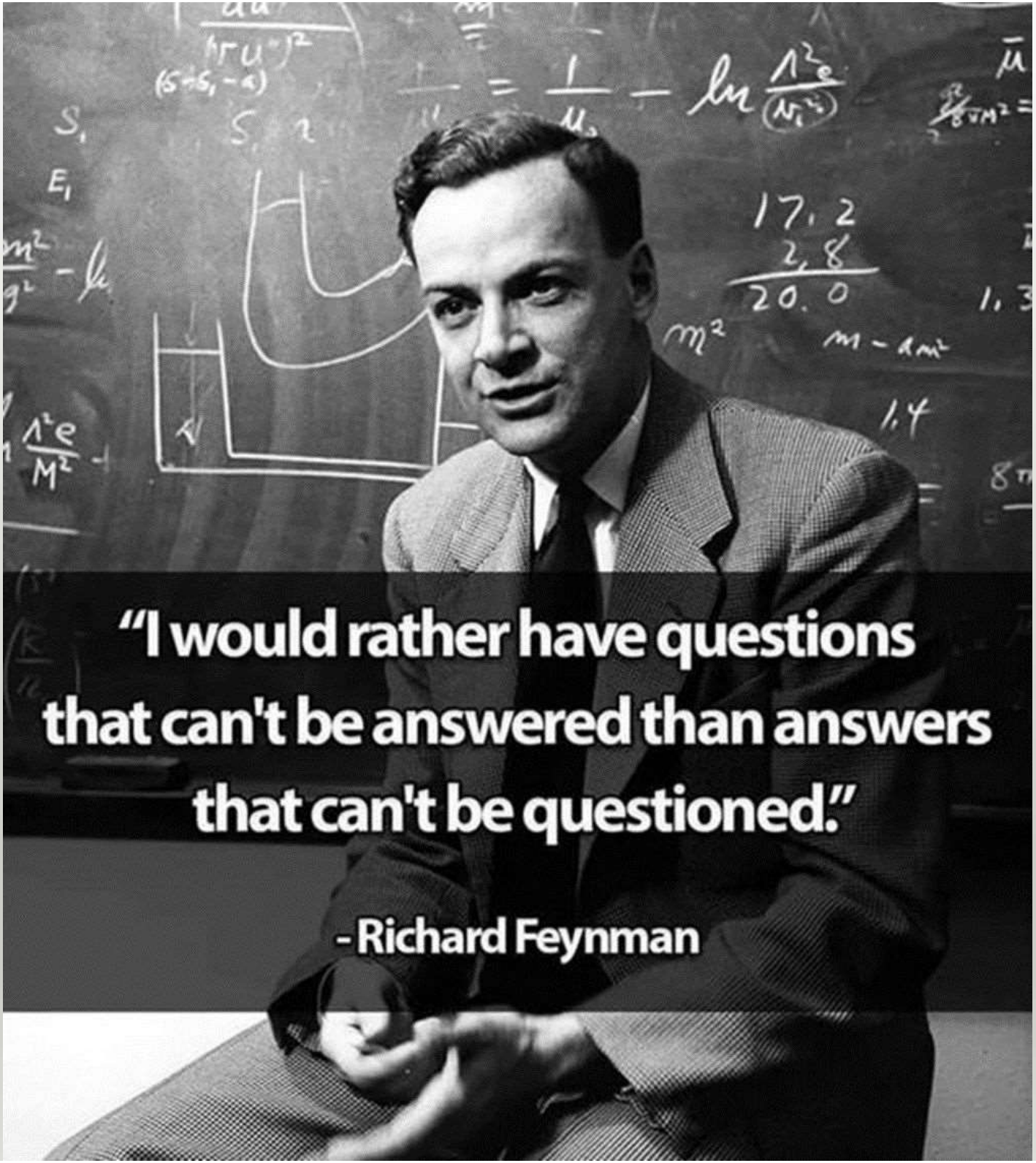
Bill Gefroh

City Of Bismarck

R8PA Conference

October 13, 2021


What's for dinner ?
Nothing .
Made by Katmin 2021
That's what we had last night !
I made enough for 2 nights .
Minions, Marvelous Minions


"I would rather have questions
that can't be answered than answers
that can't be questioned."
- Richard Feynman

Presentation Outline

Hydrogen sulfide

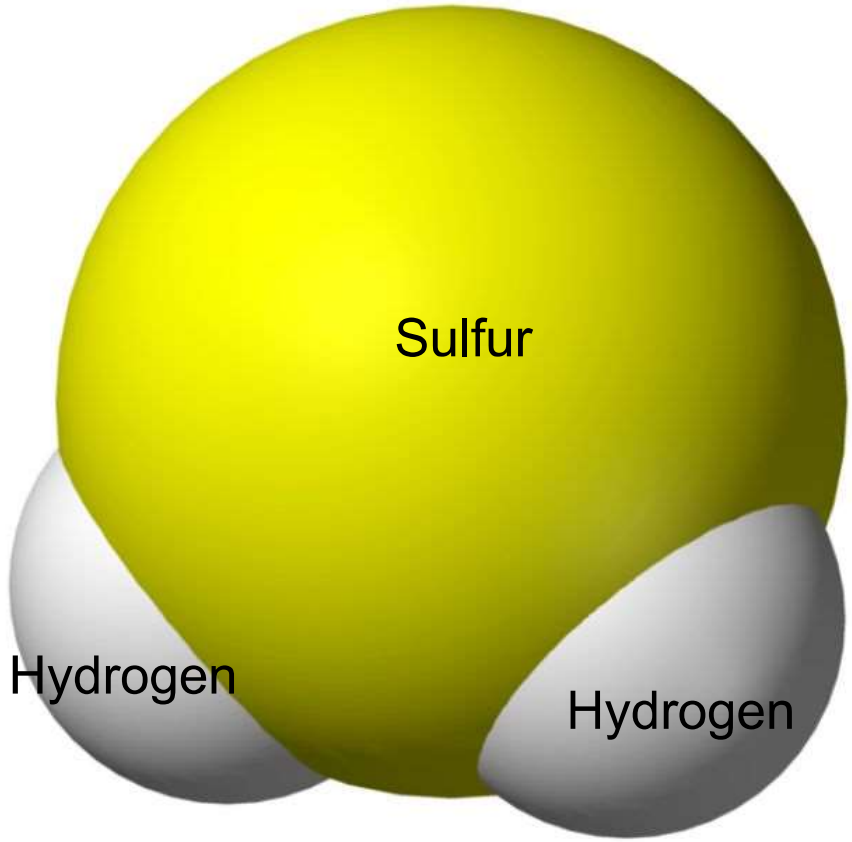
- Causes, detection and safety
- H2S data from the collection system and wastewater treatment plant
- Current treatment conditions at the WWTP
- Liquid stream chemical treatment options
- Vapor phase treatment options
- H2S jar testing and pilot testing
- Case studies monitoring and reducing H2S

Decision Parameters

1. Scope of problem and solution, system wide and at the POTW. Collect data, flow rates, asset ownership, program management, consider population changes, equipment, seasonal variations
2. Technical – most challenging, complaint driven, where is the release point
3. Aesthetics – visual, noise, heat, delivery
4. Logistics – where to place equipment. Does it need to be indoors, do vendors deliver, is renting available
5. Cost

Hydrogen Sulfide

- Colorless gas
- Rotten Egg Odor
- Heavier Than Air
- Toxic
- Corrosive
- Water Soluble



Detection Threshold - concentration of gas odor that can be detected by 50% of the people, 100% of the time.

From Minimization of odors and Corrosion in Collection System WERF 2007

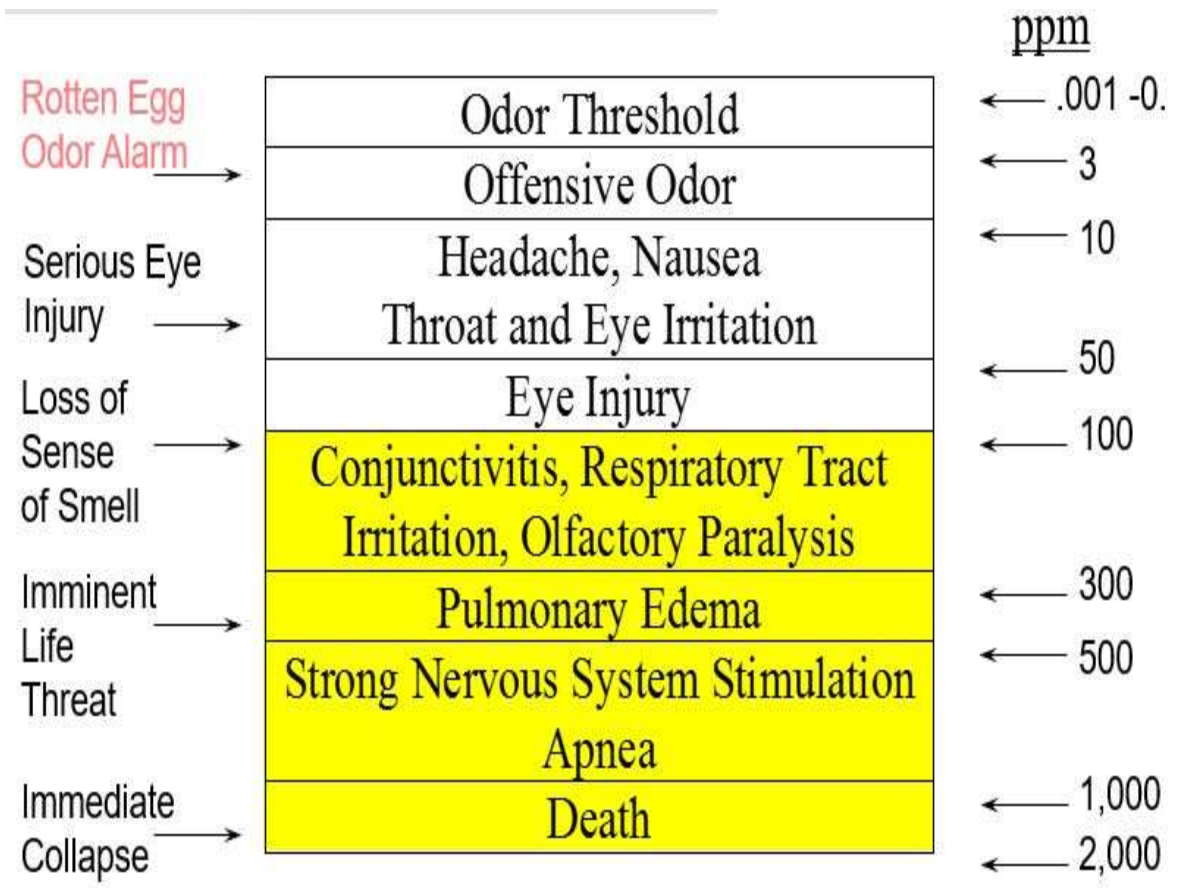
Table 2-1. Odorous Compounds in Wastewater.

Name	Formula	Characteristic Odor	Detection Threshold (ppm)
Hydrogen sulfide	H_2S	Rotten eggs	0.0005
Ammonia	NH_3	Irritating, pungent	17
Skatole	C_9H_9N	Fecal, nauseating	0.001
Indole	$C_6H_4(CH)_2NH$	Fecal, nauseating	0.0001
Methylamine	CH_3NH_2	Putrid, fishy	4.7
Allyl mercaptan	$CH_2=CHCH_2SH$	Disagreeable, garlic	0.0001
Amyl mercaptan	$CH_3(CH_2)_4SH$	Unpleasant, putrid	0.0003
Benzyl mercaptan	$C_6H_5CH_2SH$	Unpleasant, strong	0.0002
Ethyl mercaptan	C_2H_5SH	Decayed cabbage	0.0003
Dimethyl sulfide	$(CH_3)_2S$	Decayed cabbage	0.001
Trimethylamine	$(CH_3)_3N$	Pungent, fishy	0.0004
Sulfur dioxide	SO_2	Pungent, irritating	2.7
Methyl mercaptan	CH_3SH	Decayed cabbage	0.0005
Thiocresol	$CH_3C_6H_4SH$	Skunk, irritating	0.0001
Thiobismethane	CH_3SCH_3	Rotting meat	0.0011

Note: Different threshold values are reported in the literature, particularly for hydrogen sulfide and ammonia. Odor thresholds are included here to give the reader a general idea of human sensitivity and odor concentrations which could potentially cause complaints. Ammonia for example is reported in ranges from 2.8 ppm to 17 ppm.

Hydrogen Sulfide

- **Hydrogen Sulfide is Dangerous**
  - January 2017: 3 collection system workers killed in Key Largo, FL
- **Hydrogen Sulfide Corrodes Infrastructure**
  - EPA reports annual rehabilitation costs of $6,000,000,000
- **Hydrogen Sulfide Reduces Quality of Life in the Community**



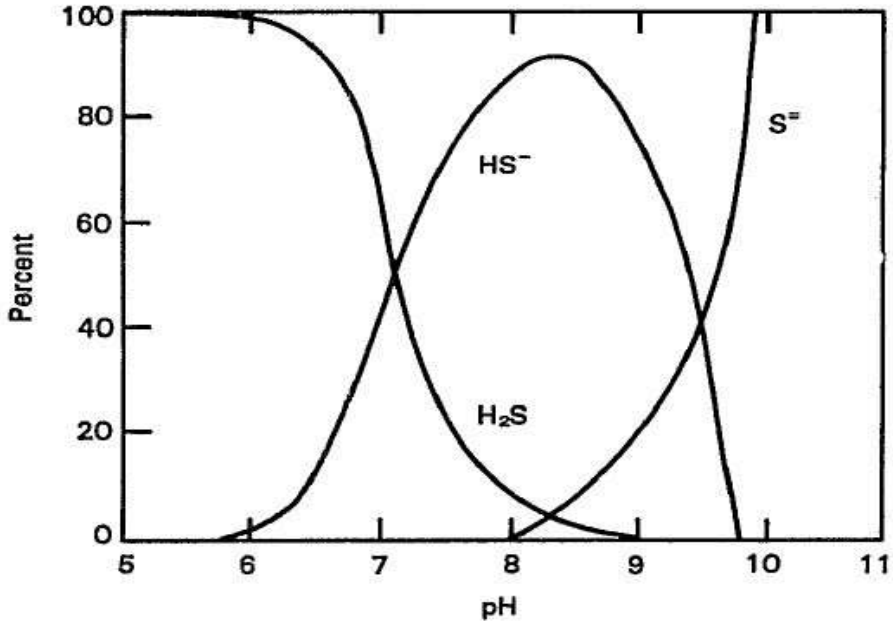
Hydrogen Sulfide Generation and Release

- Factors that influence hydrogen sulfide generation
  - Detention time
  - Temperature
  - Biochemical oxygen demand
  - pH
  - Sulfate concentration
  - Sediment and debris
- Factors that influence hydrogen sulfide release
  - Dissolved hydrogen sulfide concentration
  - Turbulence
  - pH

pH Shift – Chemicals

- Chemicals for pH shift
  - Calcium hydroxide & magnesium Hydroxide
  - Sodium hydroxide & potassium hydroxide
- Excellent at keeping sulfides solubilized
  - Does not remove sulfides, if pH decreases downstream of application, sulfides may still be released.
- Relatively Safe

- Increasing pH, chemicals work by changing the sulfide type to non-volatile.
  - $S^{=}$: non-volatile
  - HS^{-} : non-volatile
  - H_2S : volatile, can off-gas causing corrosion and odors.

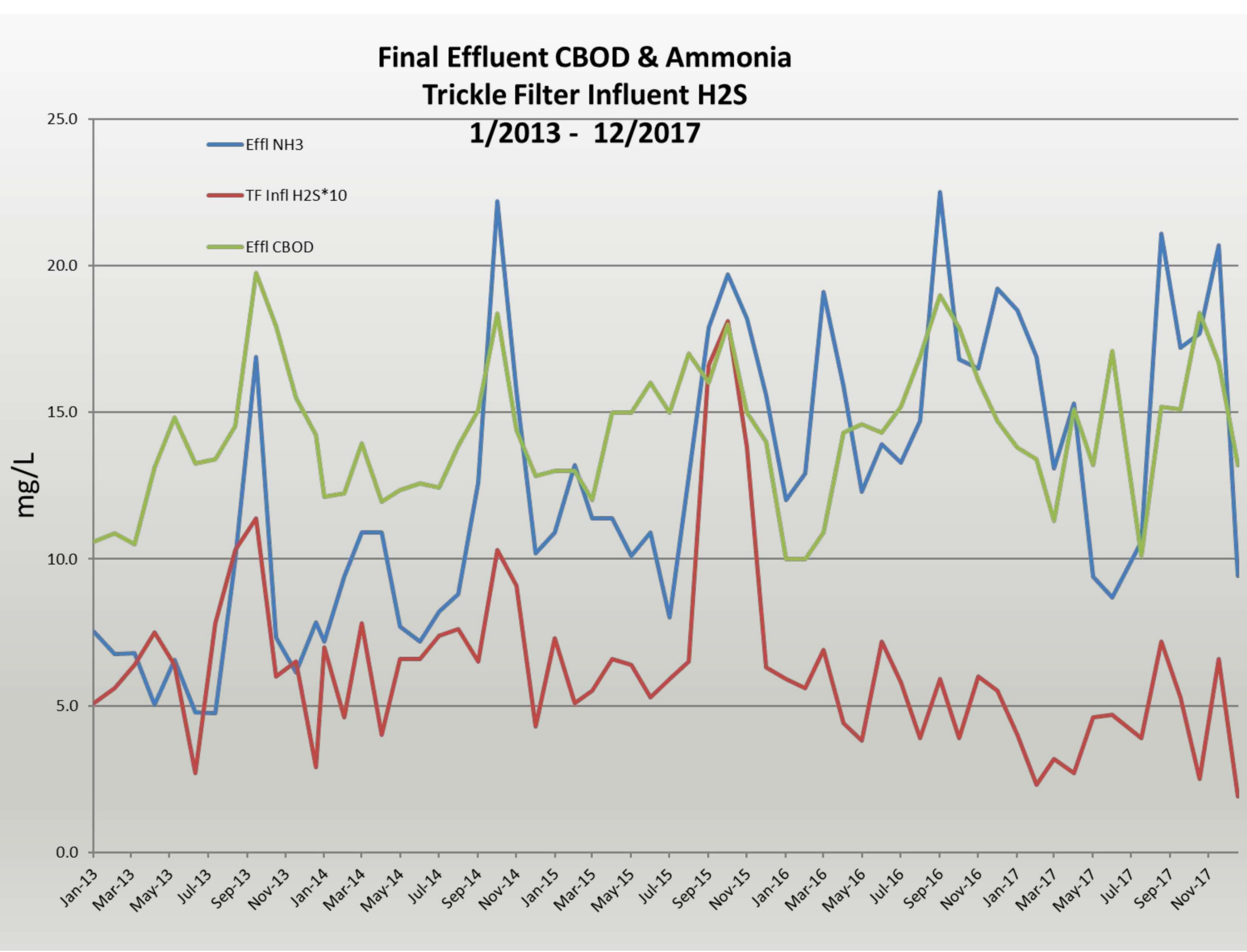


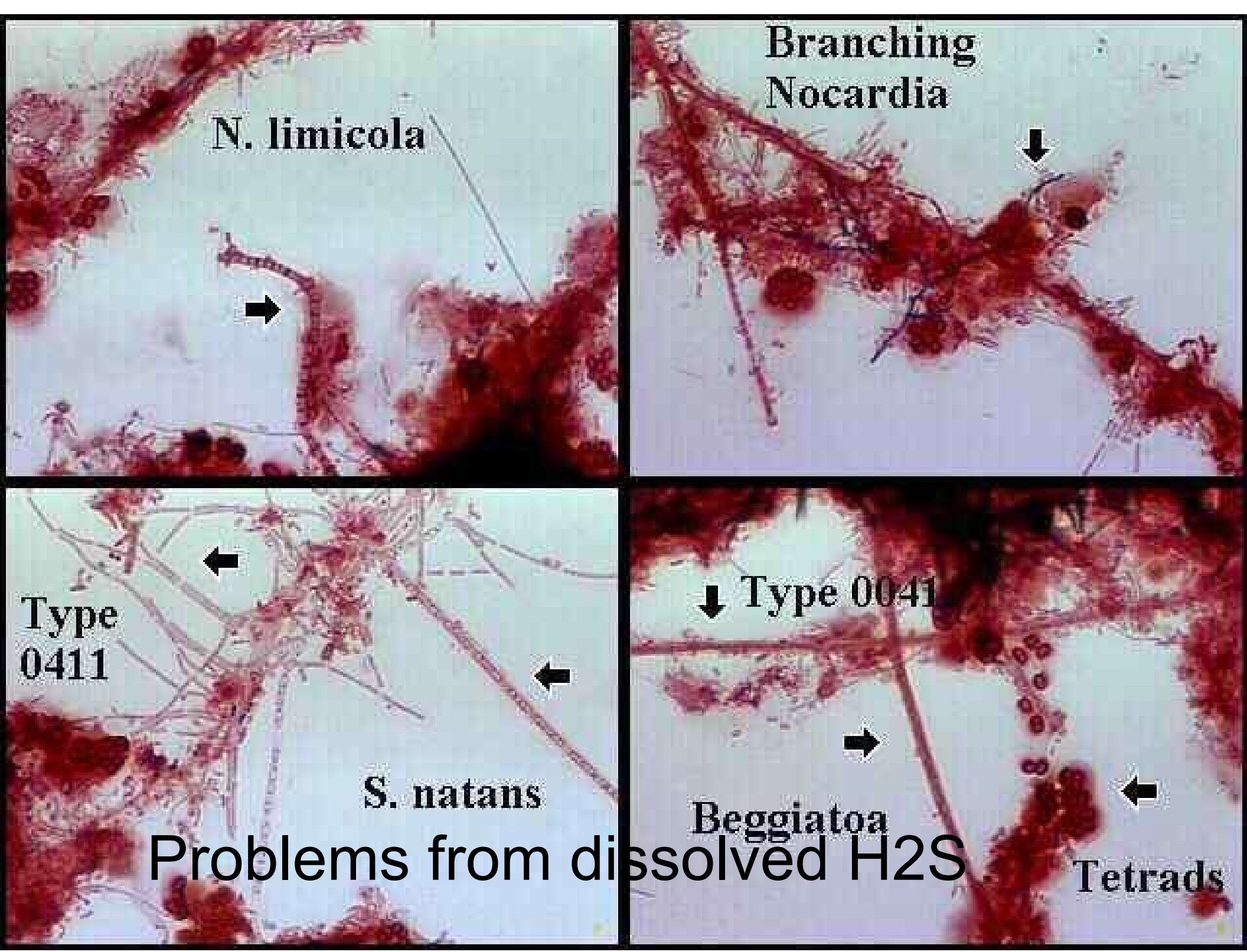
Sewer Sulfide Cycle

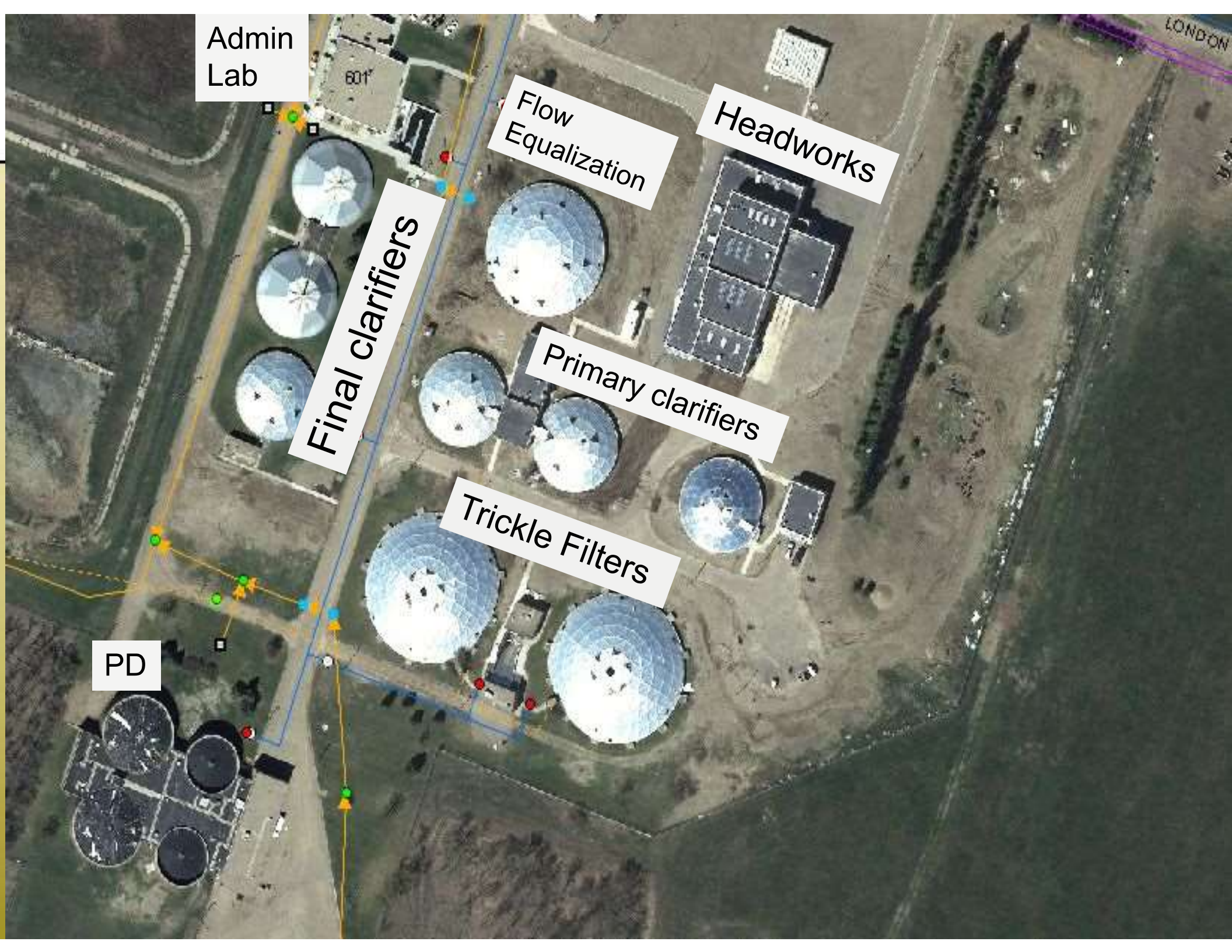
The “Sewer Sulfide Cycle” is the H2S process where natural microbiology that lives below the waterline in a sewer convert sulfate into ionic sulfide by sulfur reducing bacteria, which is then chemically changed into dissolved H2S.

The dissolved H2S is then released from the water by turbulence and splashing to exist as H2S gas.

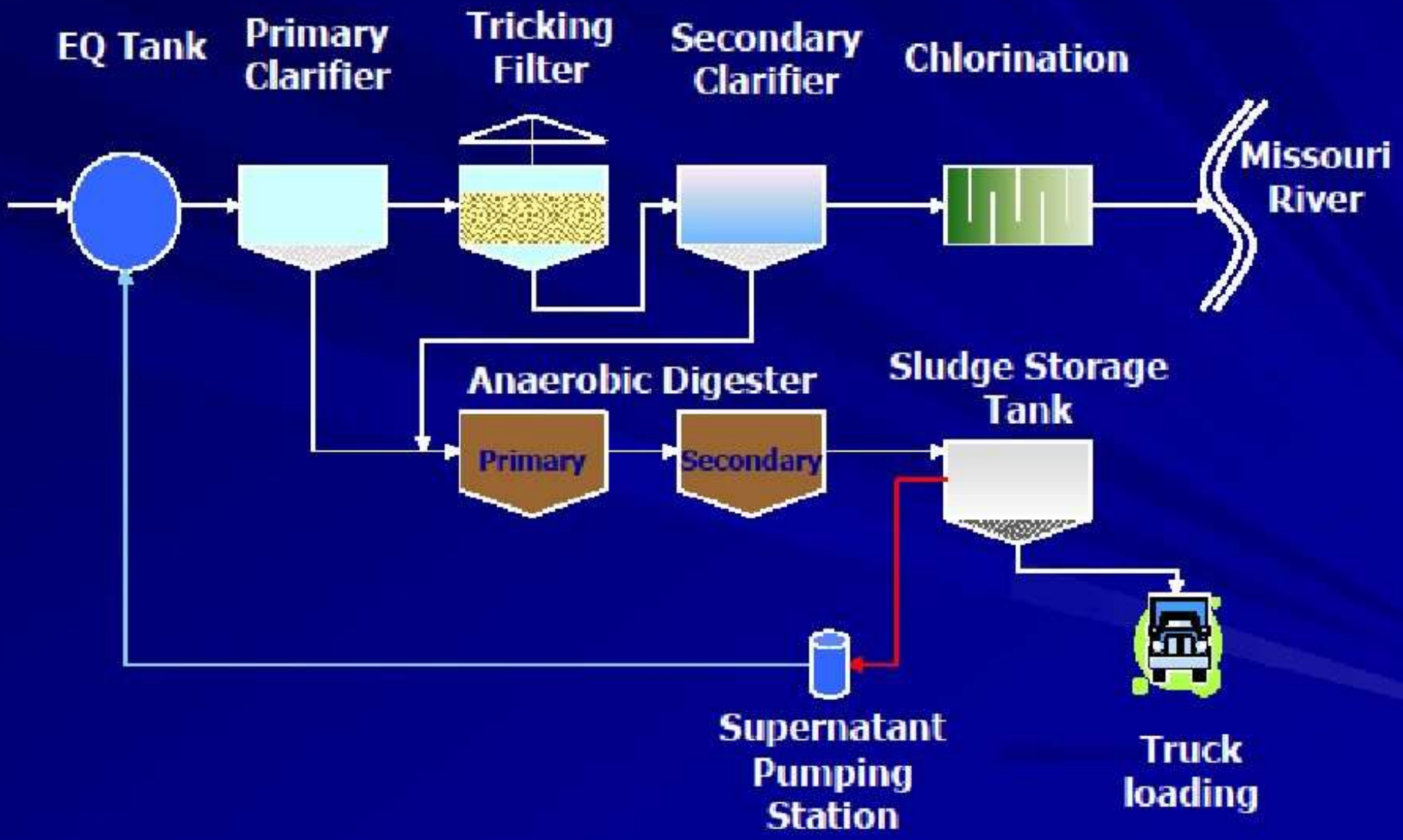
Finally, H2S gas is converted to sulfuric acid by a second type of bacteria (Thiobacillus Thiooxidans) that live above the water line; the bacteria oxidize H2S to sulfuric acid (H2SO4), the sulfuric acid drips back down into the wastewater where it is neutralized back into sulfate, and the process begins all over again.


Final Effluent CBOD & Ammonia
Trickle Filter Influent H2S
1/2013 - 12/2017
Effl NH3
TF Infl H2S*10
Effl CBOD
mg/L
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17


N. limicola
Branching
Nocardia
Type
0411
S. natans
Type 0041
Beggiatoa
Tetrads
Problems from dissolved H2S


Admin
Lab
Flow
Equalization
Headworks
Final clarifiers
Primary clarifiers
Trickle Filters
PD

Treatment Plant Process diagram



Grease Interceptor Dissolved H2S data									
FSE	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	6	5	6	5	6	5	5		2
2		8	12	6	38	20	24		20
3					15	25	45		25
4							50		6
5	10	8	25	25	2	38	50		8
6		19	25	15	20	28	15		10
7								8	39
8		12	15	10		12	25		<1
9							10		10
10									31
11									18
12									25
13			2	8	1		9		<1
14									10
15		12	5	<1	8	<1			12
16		5	5	12	10				16
17			18	10	20	30	<1		20
18		4	5	< 1	2	10	8		10
19							<1		38
20		<1	<1	6	3	15	10		Closed
21		5	6	10	20	20	14		25
22				2	8	< 2	8		3
23		5	8	19	2	2	6		2
24				12		<1	4		3

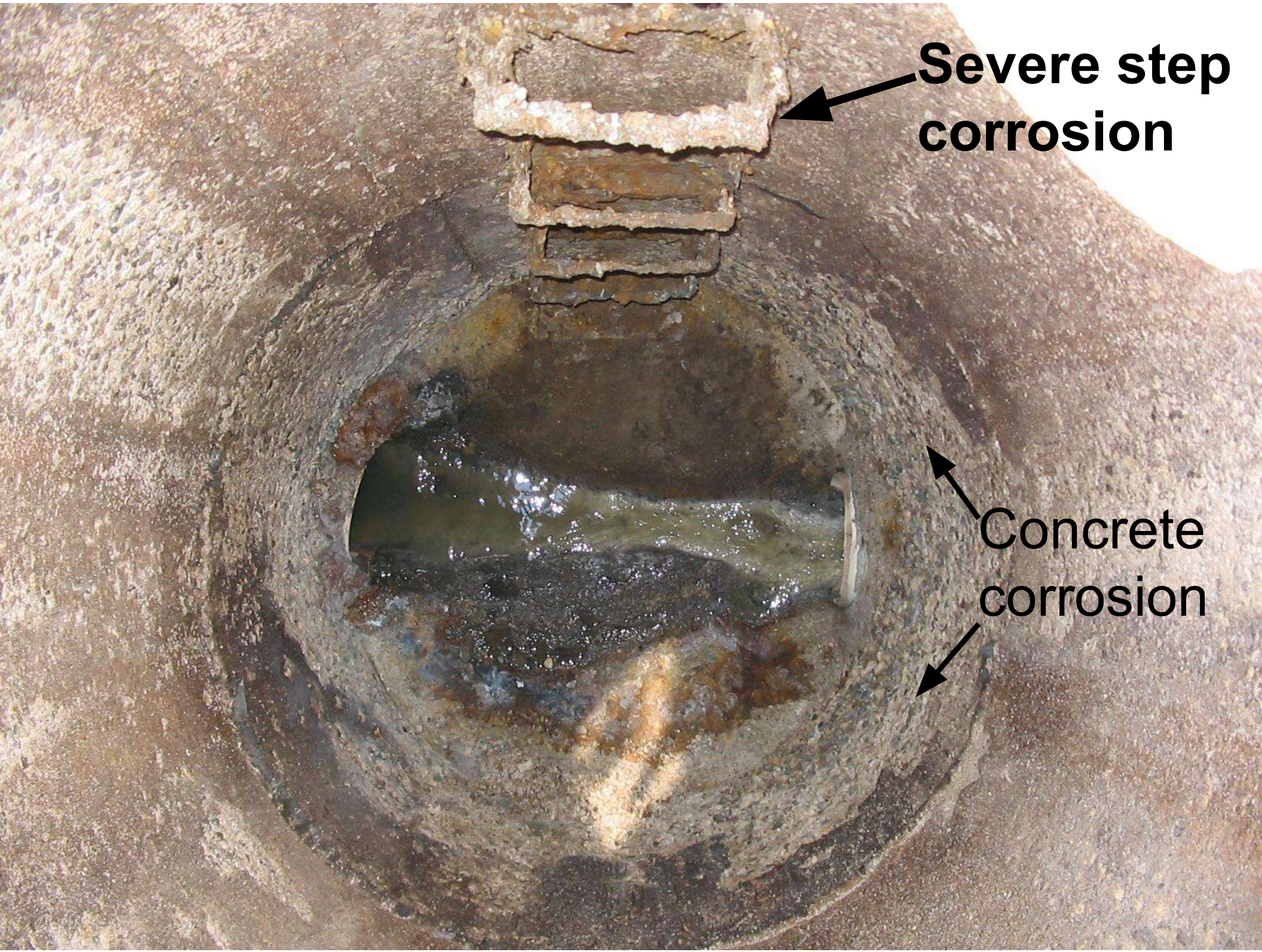
Grease Interceptor Dissolved H2S data									
FSE	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
25		12	50	88	55	20			31
26									10
27									2
28					15	10	12		25
29		4	12	10	8	20	10		3
30	12	13	8	12		8	15		6
31		12	12	6	3	8	5		2
32		18	18	7				8	12
33									1
34		21	12	9					25
35		12	15	12	25		25		15
36	3	10	<1	12	20	5	5		10
37		6	2	12	10	8	15		18
38		12	19	25	38				15
39							8		6
40		20	18	12		20	14		21
41		5	6						no data
42		15	12	31	32	20			no data
43		16	12		6	15	25	10	38
44		15	8	6	10	6			6
45			22		9	12			5
46		25	25	12	25	6	32		35
47			8	42	19				44
48		15	8	22	9				20
49	16	12	5	10	15	19	5		2
min	**3**	**4**	**2**	**6**	**3**	**5**	**5**	**8**	**1**
max	16	25	50	88	55	20	32	10	44
avg	10	14	15	22	20	13	15	9	16

Hydrogen Sulfide – Corrosion

- **Hydrogen sulfide gas is corrosive to metals and concrete**
  - **Iron – in air environment**
  - **Copper – electrical wiring**
  - **Other metallic components of wastewater systems**
    - **Structural members, gratings and walkways**
    - **Equipment (grit collectors, bar screens, conveyors, etc.)**
    - **Stainless steel**

Concrete coated ductile iron pipe corrosion at the Bismarck WWTP, due to H2S


Step corrosion


Severe step corrosion
Concrete corrosion


What is left of step


Wastewater Wet Well Corrosion from H2S


APR 11 2008

H2S Effect on Concrete

H2S (ppm)	Life expectancy (Years) for 3″ diameter pipe, 1″ cover
0.5	>50
1	25 - 50
1.5	25
2	10-25
3	10
4	5-10
7	5
>7	<5

Advanced Oxidation Technology, Buck Cox PhD, February 2004

Barrel Screens –removes large objects, smaller sized inorganics (gravel) and some organics. The high turbulence volatilizes H2S. Week of October 20, 2017, average H2S 161 ppm. Peak was at 400 ppm. May 2018 peak was at 1000 ppm.

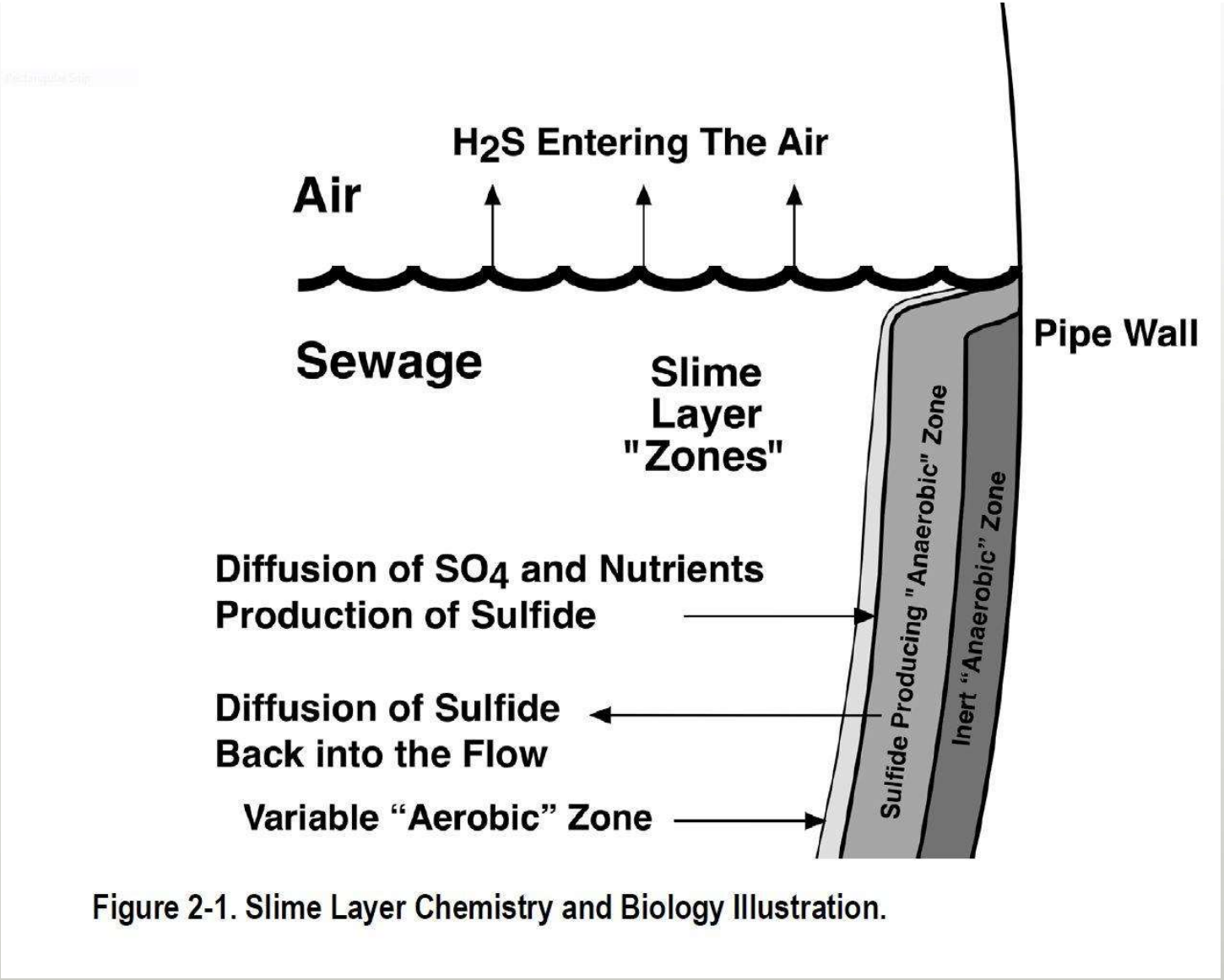


Figure 2-1. Slime Layer Chemistry and Biology Illustration.

A slime layer develops after two weeks in new sewers and becomes permanent.

There are three zones in the gelatinous slime layer

- Variable Aerobic zone,
- Anaerobic zone, H_2S production
- Inert Anaerobic zone, fermentation

Minimization of Odors and Corrosion in Collection Systems Phase 1 WERF 2007

Biological ORP Scale

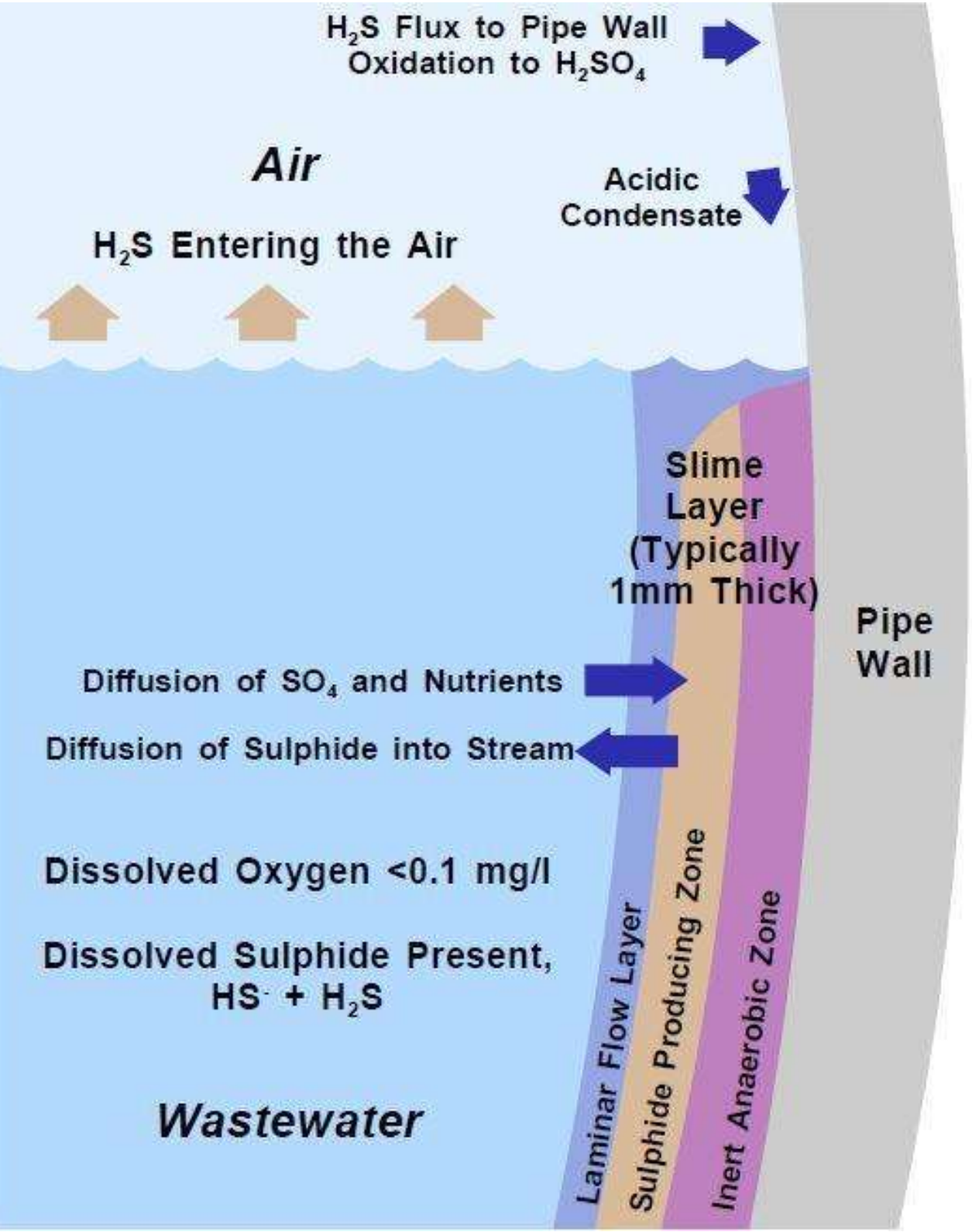
ORP (mV)	Process	Compound(s) Present	Zone	Products
+ 300 to + 200	A	O_2	Aerobic	Carbon Dioxide (CO_2) + Water (H_20)
+ 100 to 0	A, B	NO_3-/NO_2	Sulfide-Producing Anaerobic	Nitrogen Gas (N_2) or Sulfide (S^{2-})
0 to - 100	B	SO_4	Sulfide-Producing Anaerobic	Nitrogen Gas (N_2) or Sulfide (S^{2-})
- 100 to - 200	C	Organic Carbon Compounds	Inert-Anaerobic	Fermentation Products and Methane (CH_4)
- 200 to - 300	C, D	Organic Carbon Compounds	Inert-Anaerobic	Fermentation Products and Methane (CH_4)

A = Organic Carbon Oxidation
B = Denitrification if Nitrate/Nitrite Present
C = Sulfate Reduction w/o Nitrate/Nitrite Present
D = Fermentation and Methane Generation

Minimization of Odors and Corrosion in Collection Systems Phase 1 WERF 2007

ORP: Oxidation Reduction Potential

- > +50mV, aerobic, bacteria byproducts are CO_2 and water.
- 0 to -50 bacteria use NO3 byproducts are nitrogen gas.
- - 50 to -200 mV, anoxic, SO_4, bacteria convert sulfate to S^{-2} and H_2S.
- < -200mV fermentation. bacteria byproducts are methane and CO_2.



Minimization of Odors and Corrosion in Collection Systems
Phase 1 WERF 2007

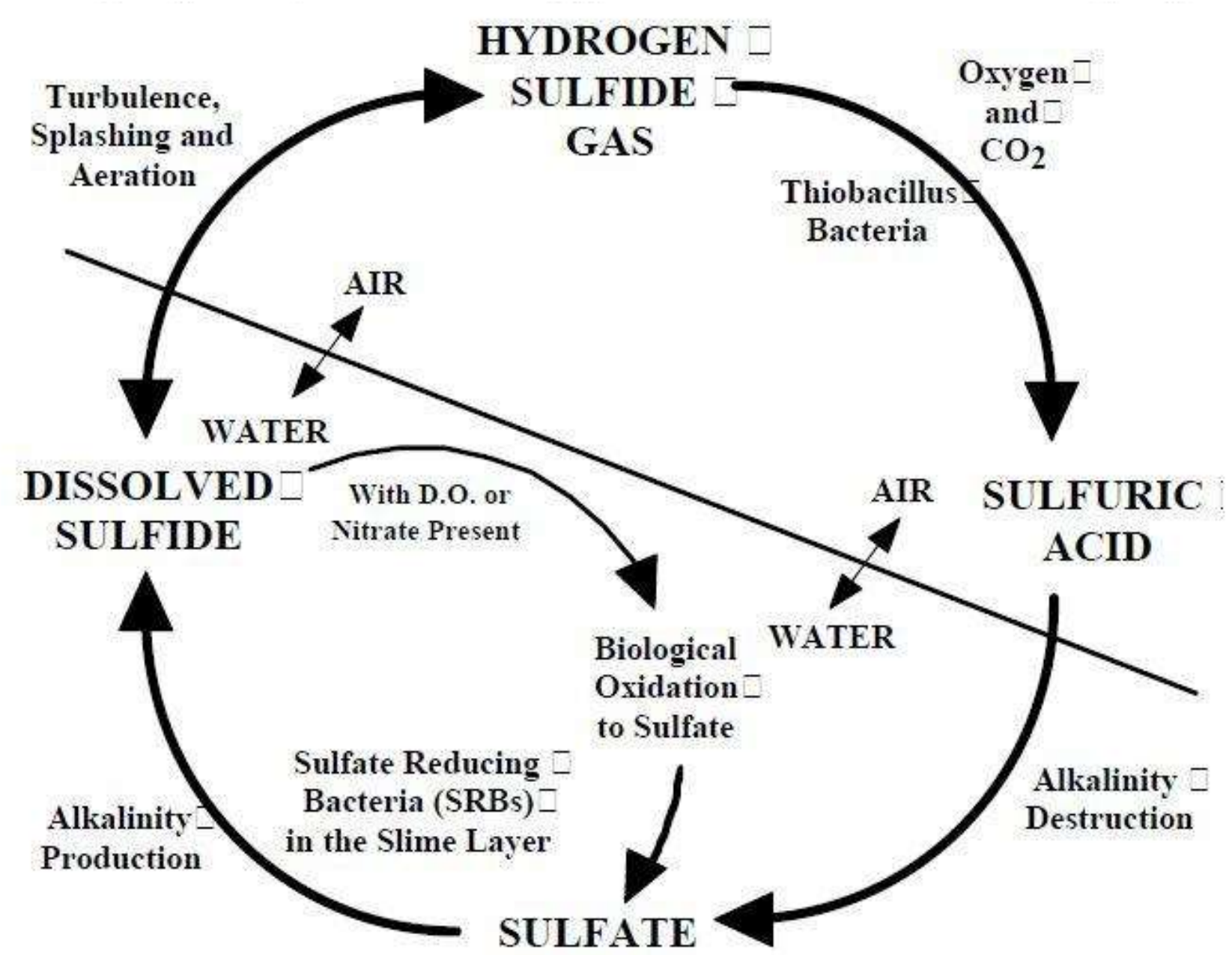


Figure 2-7. The Sewer Sulfide Cycle.

Sulfide types

Sulfide equilibrium equation, H_2S (g) ⇌ H_2S (aq) ⇌ HS^- ⇌ S^{-2}

1. S^{-2}, sulfide ion, non volatile, does not contribute to odors.
2. HS^-, bisulfide or hydrosulfide ion, can only exist in solution
3. H_2S, hydrogen sulfide, can exist as a gas dissolved in water, can leave water to exist as a free gas. The rate it leaves is governed by Henry's law and is **very dependent upon turbulence and pH**. H2S and corrosion are increased significantly at points or turbulence. When dissolved H_2S is released into the gas phase, the bisulfide ion is immediately transformed into more aqueous H_2S to replace what was lost.
   Sulfuric acid is produced by *thiobacillus* bacteria that colonize on the crown of pipes, walls and other surfaces above the water line in wastewater pipes and structures occurs when the air H2S is >2 ppm. Simplified equation, H_2S (g) + $2O_2$ → H_2SO_4. The effects on concrete can be devastating. This only occurs under aerobic conditions.

H2S Prevention

1. Preventing the 1st pathway, sulfate to sulfide is difficult, it can be done by pigging to scrape off the soft biological slime layer, using anthroquinone (metabolic inhibitor) and caustic slugs. The slime layer grows back in 3 – 10 days depending on temperature and BOD.

2. Interrupting the 2nd pathway is the most common using chemicals and liquid phase options. Oxygen injection, chemical addition using nitrates, iron salts, peroxide, potassium permanganate and chlorine. Using ferric chloride and ferric sulfate can provide more efficiency. Design drop structures and manholes with drop pipes to reduce turbulence. Discharge force mains below a body of water. Strip the H_2S in a location where facilities have been designed to handle the conditions.

H2S Prevention Continued

3. Interrupting the 3rd pathway, preventing sulfuric acid formation, by surcharging sewers, crown spraying and ventilation.
   - Surcharging sewers “crown cutting” or “crow corrosion” can occur from entrapped air bubbles in the flow that coalesce on the pipe crown in a place where bubbles can remain stationary against hydraulic forces at a high spot or at a joint in reinforced concrete pipe.
   - Ventilation will never be able to stop corrosion, it will help to remove moisture and H2S. Ventilation needs to be done with other measures to be effective.

4. Interrupting the 4th pathway by protecting corrosion prone surfaces.
   - Usage of plastics/glass (PVC, HDPE, PP, PE, Fiberglass and Fiber Reinforced Plastics).
   - Coatings on concrete is the most common, mostly epoxies and resins are used, cast-in-place liners for new concrete pipe and rehabilitation of pipes.


HAVE YOU
EVER NOTICED
THAT A WOMAN'S
"I'LL BE READY
IN 5 MINUTES"
AND A MAN'S
"I'LL BE HOME
IN 5 MINUTES"
ARE EXACTLY THE SAME?


DEAD MAN WALKING
HIS
HERS
©Tundra 2020

H2S Effect on Concrete

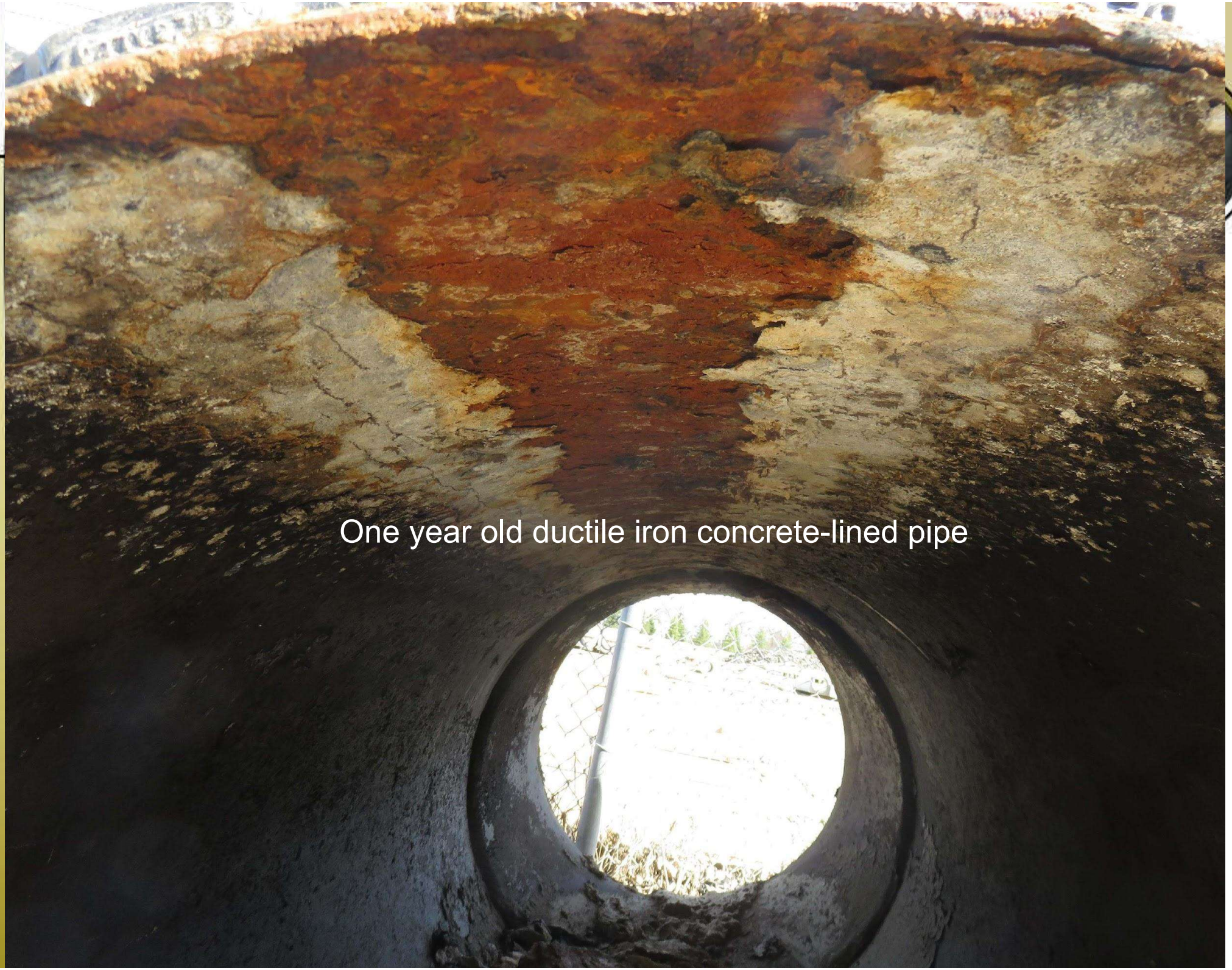
Table 9-1. Concrete Pipeline Corrosion Rates.

H_2S Concentration, ppm	Corrosion Rate, in./yr	
	In Cast Pipe	In Spun Pipe
<1	<0.03	<0.02
1–3	0.03–0.05	0.02–0.03
3–8	0.05–0.08	0.03–0.05
>8	>0.08	>0.05

Minimization of Odors and Corrosion in Collection Systems Phase 1 WERF 2007


Three – year old diversion vault


MAYFLOWER


One year old ductile iron concrete-lined pipe

So What Are the Options?

- Liquid phase removal options
  - Reduce H2S in wastewater to prevent release to atmosphere.
    - Nitrate Salts
    - Iron Salts
    - Oxidizers
    - Oxygen
  - Capture sulfides to prevent release to atmosphere
    - Magnesium Hydroxide, Phase changer. Alkaline dosing to increase the pH to 8.5 – 8.8.
    - Calcium Hydroxide
- Vapor phase removal options
  - Remove hydrogen sulfide by passing it through
    - Biofiltration
    - Bioscrubber
    - Carbon Adsorption
    - Wet Chemical Scrubbing

Caustic Cleaning of Sewer Lines

Liquid Phase Odor Control

Liquid phase options

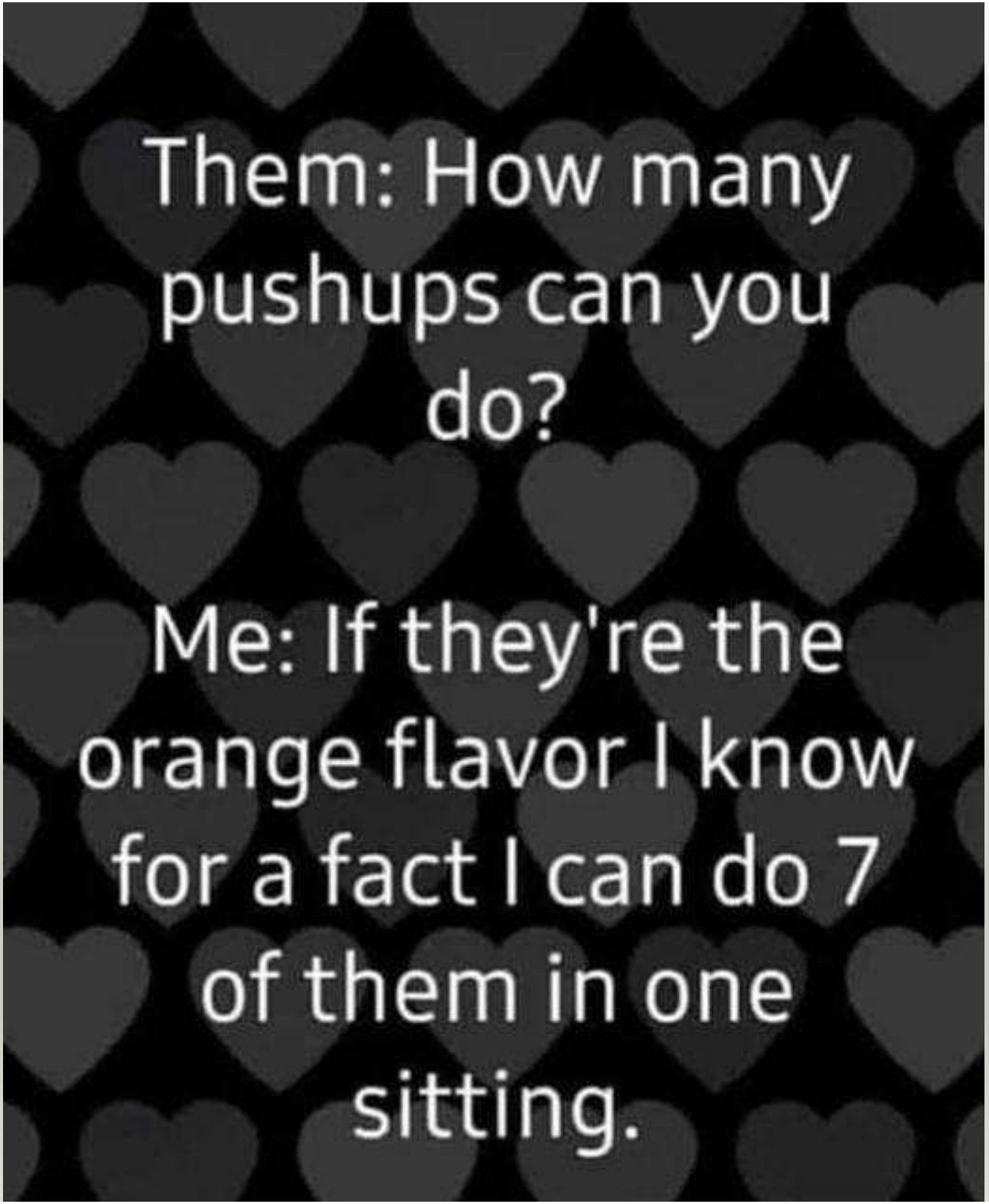
1. Calcium nitrate
    - Bioxide and Bioxide blends from Evoqua. Two gallons Bioxide/pound H2S.
    - Aqua Hawk HSX (calcium nitrate) from Hawkins Water Group
2. Oxidizers
    - Hydrogen Peroxide, Chlorine. About 4 mg/L Cl2/mg/L H2S.
3. Oxygen Injection
4. Iron Salts
    - Ferric Chloride, Ferrous Chloride
5. pH Shift
    - Hydroxides


Ferric chloride addition


Chemical injection site

Therapist: Your wife says you never buy her flowers is that true?

Him: To be honest, I never knew she sold flowers.


Them: How many pushups can you do?
Me: If they're the orange flavor I know for a fact I can do 7 of them in one sitting.

Nitrate Salt Summary

Calcium Nitrate or Sodium Nitrate and derivatives

- Very High Degree of Odor Control
  - Easy to optimize
    - Residual nitrate can be easily tested
  - Capable of preventing and removing 100% of sulfides
- Moderate Cost
- Non-Hazardous
- Basic formulations are available nationally. Some blends only available regionally.

Bioxide – Prevention Mechanism (continued)

The end product of microbial respiration

1. Oxygen → Carbon Dioxide and Water
2. Nitrate → Nitrogen gas
3. Sulfate → Hydrogen Sulfide

- The presence of calcium nitrate in anoxic wastewater prevents the formation of hydrogen sulfide by providing the microbiology with an "easier to breathe" terminal electron acceptor
- Without Nitrate:
  - $SO_4^{=} + C \rightarrow \mathbf{S^{=}} + H_2O + CO_2$
- With Nitrate:
  - $2NO_3^{-} + 3C \rightarrow 3CO_2 + \mathbf{N_2}$

Oxygen

Oxygen is the most efficient method for H2S control, if facilities can make it work. Determine the uptake rate performing a jar test. Jar testing may underestimate the oxygen consumption rate. The actual oxygen demand could be as high as 10 mg/L/hr. if the jar test demand is at ~4 mg/L/hr. If the demand is 10 mg/L/hr. and the force main detention time is 10 hours, the dose would be 100 mg/L. Oxygen can be added up to 40 mg/L under no pressure and up to 120 -300 mg/L under pressure. Seattle WA, diurnal season variations from 8-18 mg/L oxygen demand. Onsite oxygen manufactures ECO_2, bubble system. BlueInGreen - SDOX-CS® pressure system. Gener-Ox™ pressure system. All are good systems.

- Low levels of dissolved oxygen can be used to oxidize and remove existing sulfides from the water before they can strip out as H2S in sensitive areas. It takes 5 – 20 minutes to oxidize existing dissolved sulfides. Need 2 mg/L oxygen per 1 mg H2S.
- Innovative and highly effective, SuperOxygenation technology is an ecofriendly alternative to traditional chemical treatments for water and wastewater.

Water

Adding water can add air, chlorine and it will reduce the detention time.
In particular for small diameter pipes. is the most efficient method for H2S control, if facilities can make it work. Determine the uptake rate performing a jar test. Jar testing may underestimate the oxygen consumption rate. The actual oxygen demand could be as high as 10 mg/L/hr. if the jar test demand is at ~4 mg/L/hr. If the demand is 10 mg/L/hr. and the force main detention time is 10 hours, the dose would be 100 mg/L. Oxygen can be added up to 40 mg/L under no pressure and up to 120 -300 mg/L under pressure. Seattle WA, diurnal season variations from 8-18 mg/L oxygen demand. Onsite oxygen manufactures ECO_2, bubble system. BlueInGreen - SDOX-CS® pressure system. Gener-Ox™ pressure system. All are good systems.

Bioxide – Removal Mechanism

- If hydrogen sulfide is already present at the location where calcium nitrate is added, the microbiology can remove the hydrogen sulfide.
  - $8NO_3^- + \mathbf{5H_2S} \rightarrow \mathbf{5SO_4^=} + \mathbf{4N_2} + 4H_2O + 2H^+$
- The reaction requires about **90** minutes of contact time to complete

Bioxide – Application Guideline

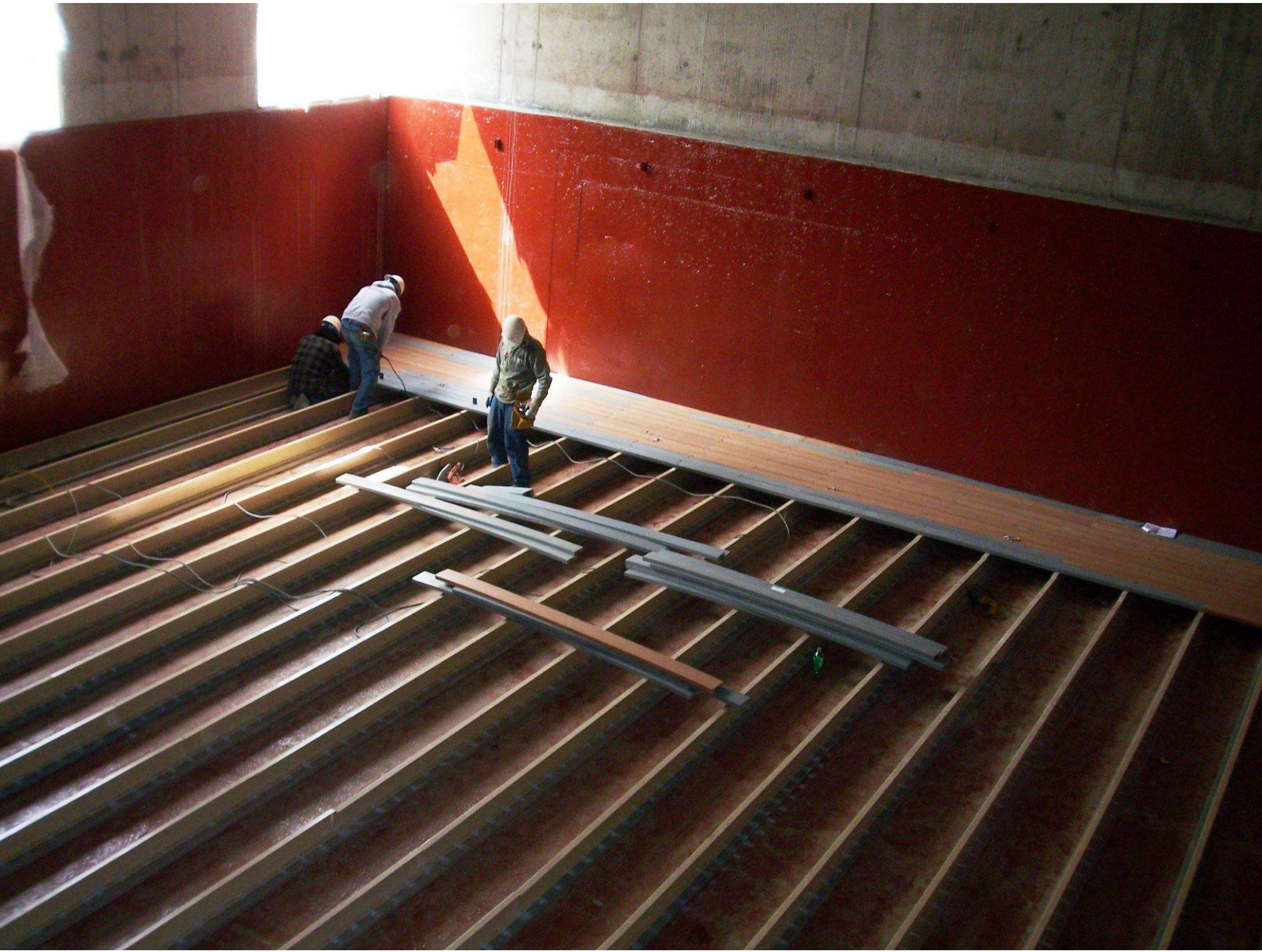
- Bioxide is best used:
  - At pump stations and along force main injection points
  - For retention times ranging from 1.5 to 12 hours
  - When chemical safety is a concern
  - When hydrogen sulfide goal is very strict

Iron Salt – Product Line Summary

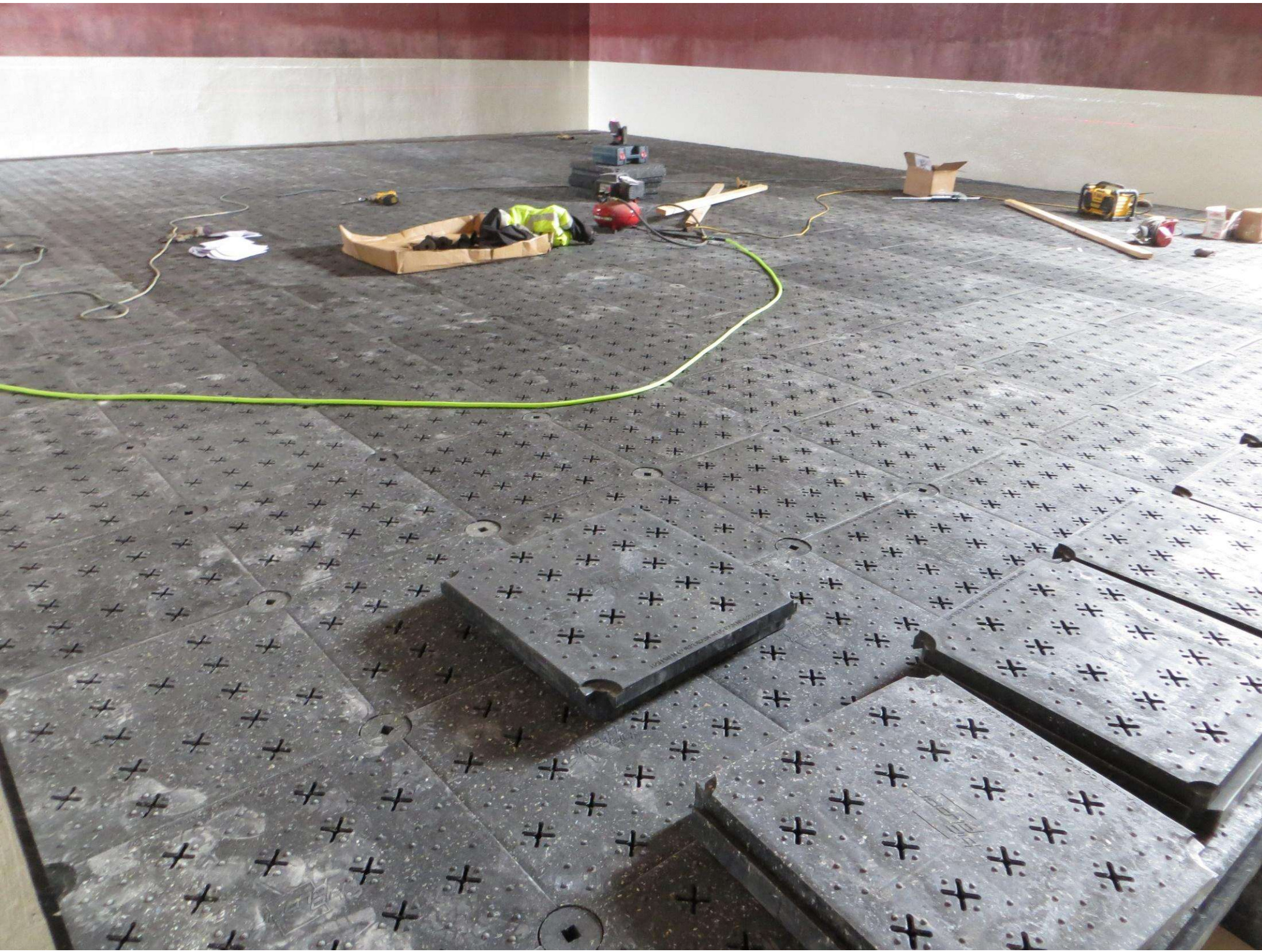
- Iron Salts are available in a variety of blends:
  - Ferric Sulfate and Ferrous Sulfate
  - Ferric Chloride and Ferrous Chloride
- Lesser Degree of Odor Control
  - Acidity of solution drives sulfide out of solution
  - Only capable of removing existing sulfides
- Iron Salts remove sulfide from solution by combining with them and forming a solid. Precipitated metal sulfides are very insoluble
  - $Fe^{2+} + HS^{-} \rightarrow FeS + H^{+}$
  - $Fe^{2+} + 2Fe^{3+} + 4HS^{-} \rightarrow Fe_3S_4 + 4H^{+}$

Bismarck WWTP Vapor Phase Odor Control

Biofilter for Odor/H2S Removal




S300
Bobcat




DMI
INDUSTRIES

Action Plan to Reduce Odors

Develop and determine the desired objective

- Use GIS, map the wastewater collection system
- Collect data
- Consider treatment options
- Perform lab bench testing
- Perform pilot testing
- Analyze data

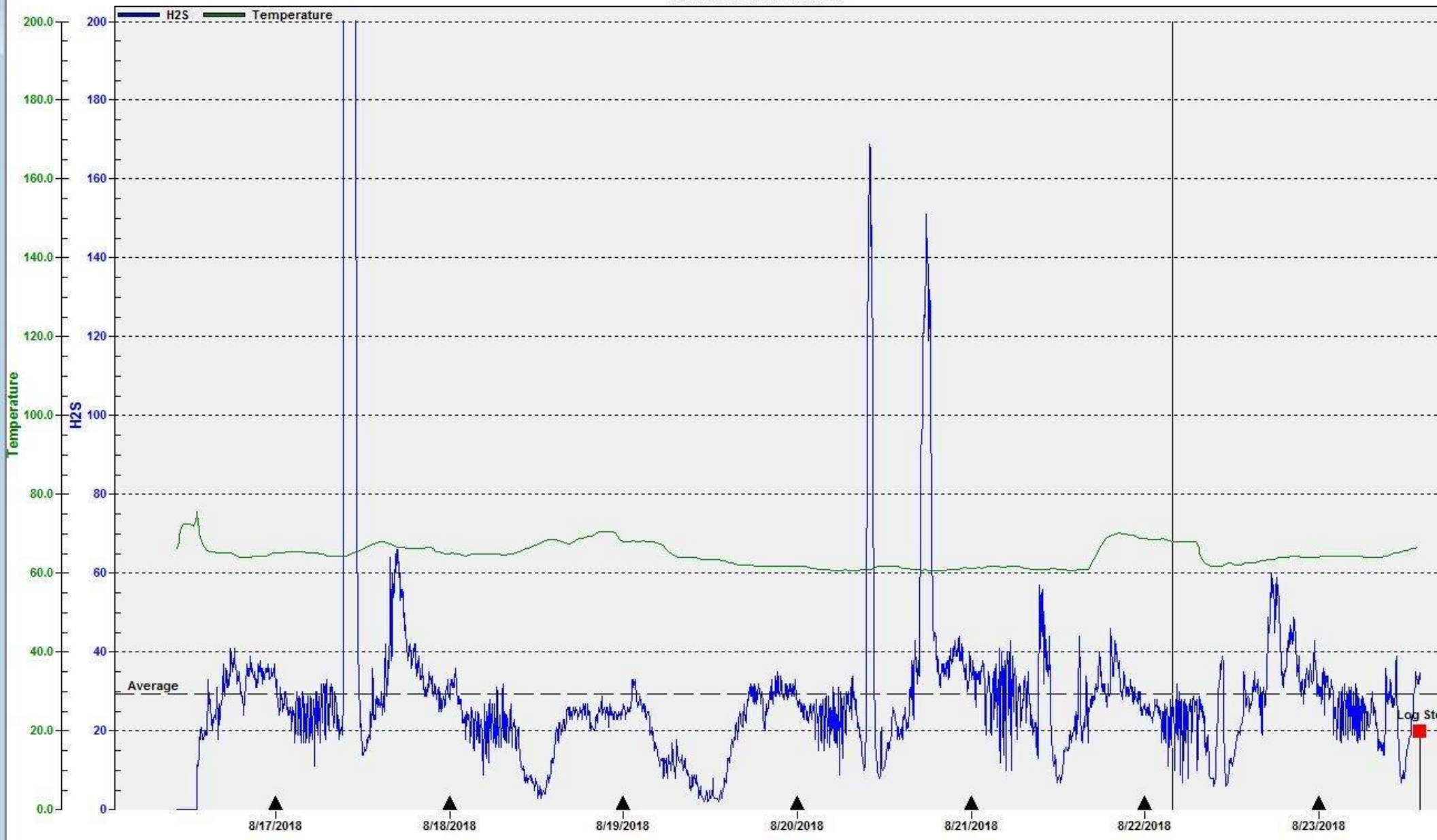
Hydrogen Sulfide Test Kit,
Model HS-WR, Color Disc
Product # 22380


GAS MIXTURE
GAS COMPOSITION
PRAXAIR
GAS
Gas Composition
PRAXAIR
2-28-11
COMPRESSED GAS, N.O.S.
UN1956
Refillable Cylinder
PRAXAIR
GAS
Gas Composition
PRAXAIR
OdaLog
H2S
OdaLog
H2S
H2S
H2S
OdaLog
H2S
Gas Logger
H2S
MSA ALTAIR 4X
GASALERTMICRO 5 PID
GASALERTMICRO 5
GASALERTMICRO
GASALERTMICRO
New O2
IN Side

C:\OdaStat-G\olgfiles\Biorem 8-23-2018_Session 1.olg

Biorem 8/16/18 - 8/23/2018

Biorem 8-23-2018: Session 1

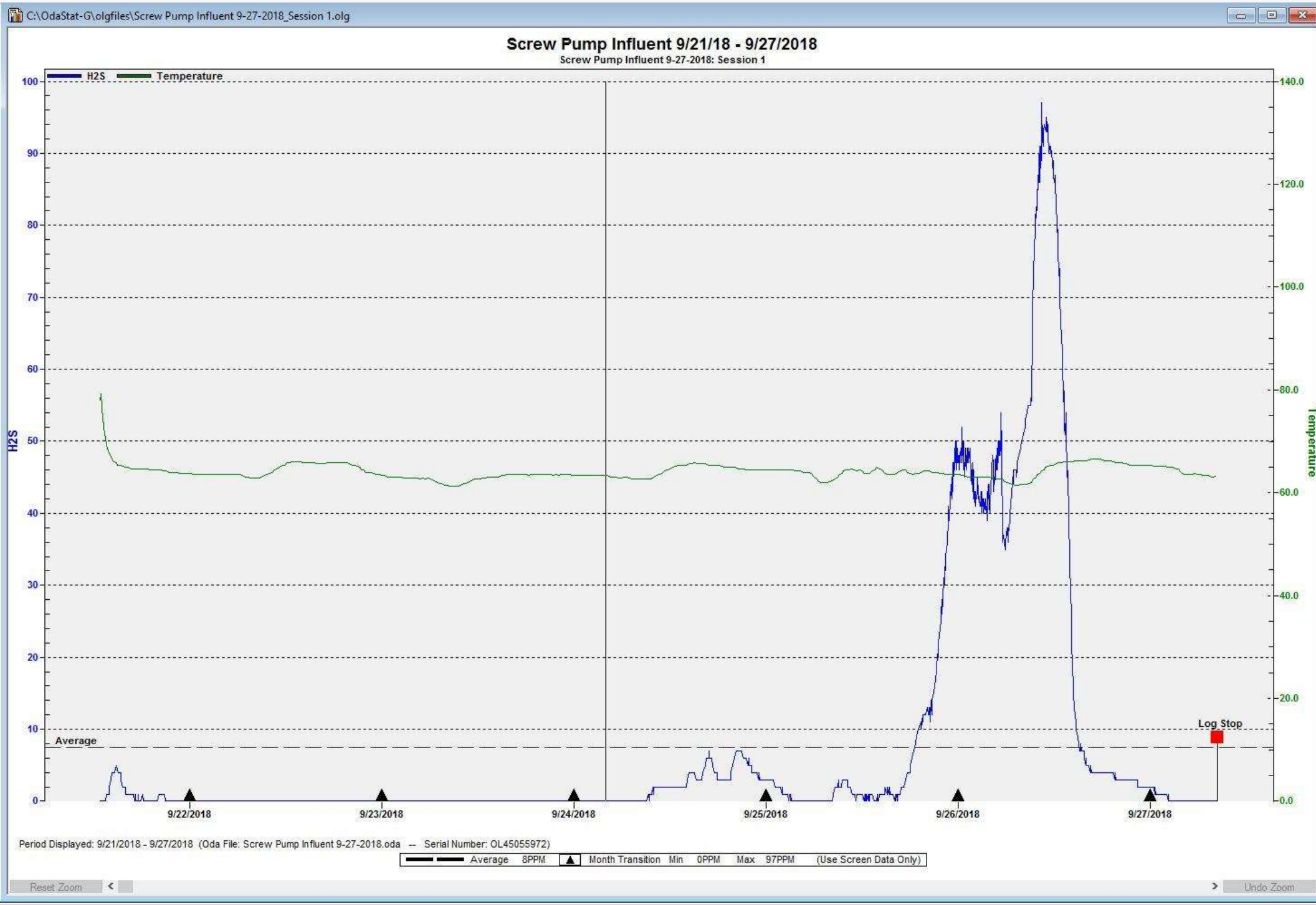


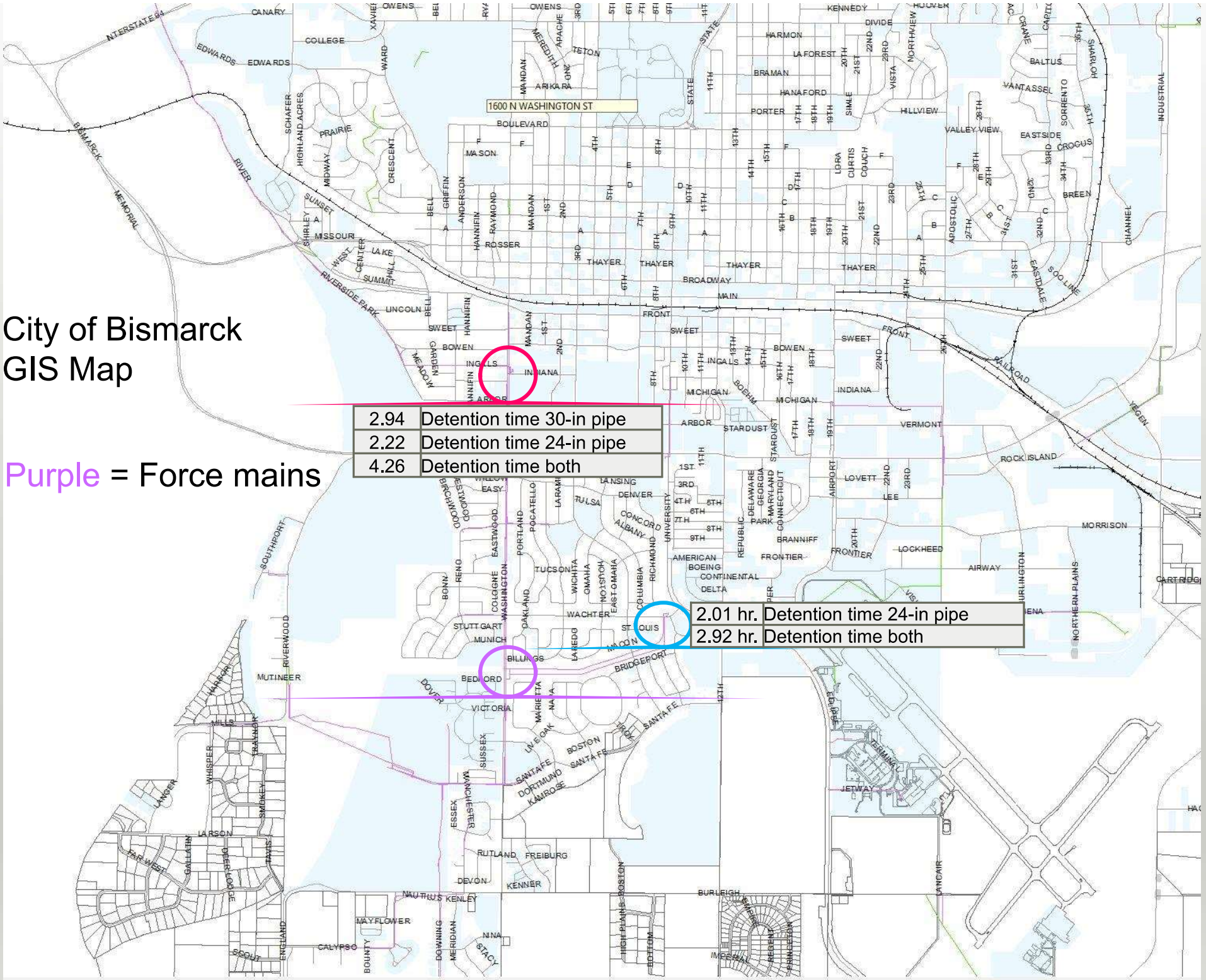
Period Displayed: 8/16/2018 - 8/23/2018 (Oda File: Biorem 8-23-2018.oda -- Serial Number: Odalog Type L2-RTx 03810968 Instrument Range 0-0PPM)

Average 29 | Day Transition Min 0 Max 392 (Use Screen Data Only)

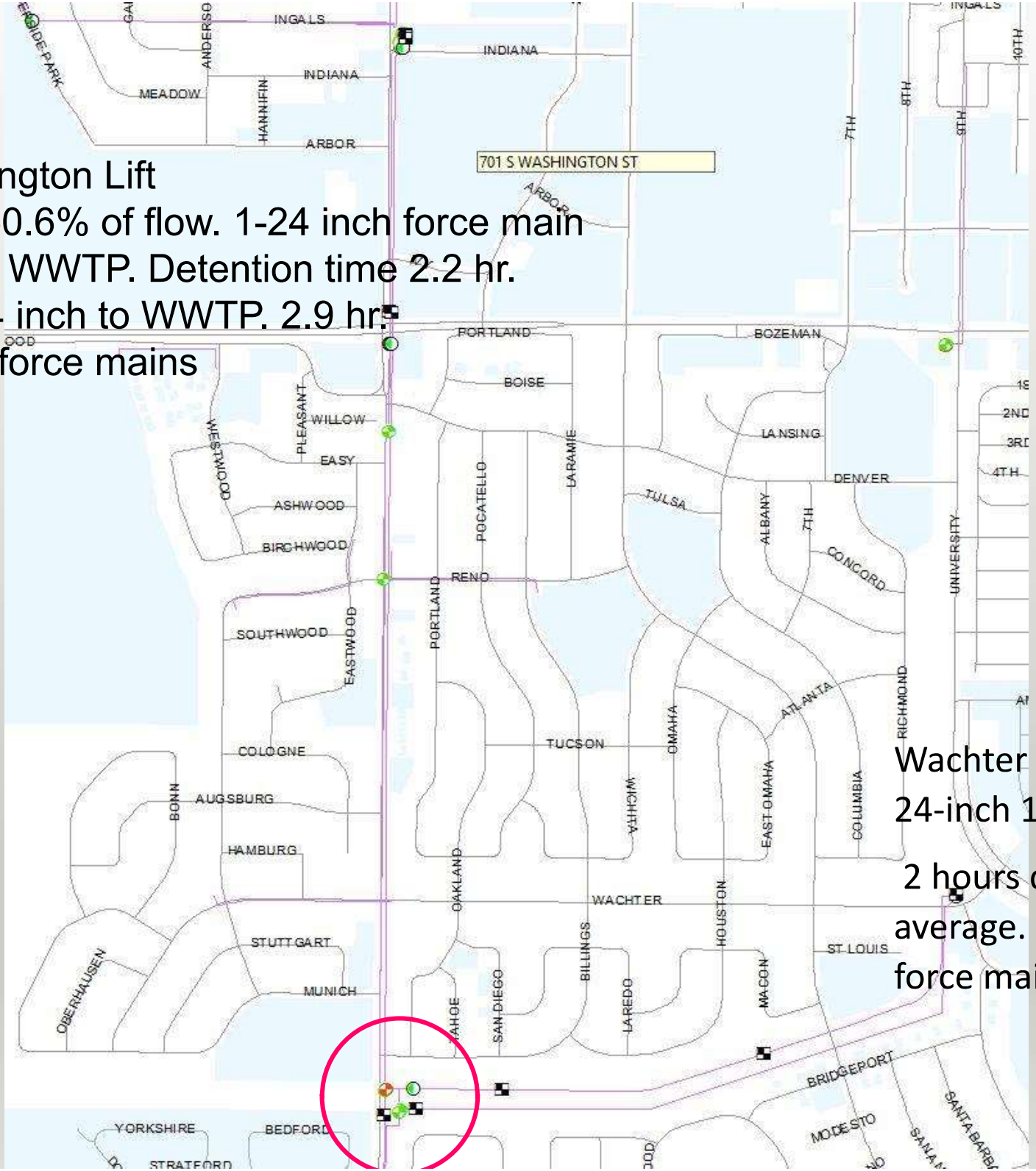
Reset Zoom


Screw
Pump
Infl.
e Earth


C:\OdaStat-G\olgfiles\Screw Pump Influent 9-27-2018_Session 1.olg
Screw Pump Influent 9/21/18 - 9/27/2018
Screw Pump Influent 9-27-2018: Session 1
H2S
Temperature
100
90
80
70
60
50
40
30
20
10
0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Average
Log Stop
9/22/2018
9/23/2018
9/24/2018
9/25/2018
9/26/2018
9/27/2018
Period Displayed: 9/21/2018 - 9/27/2018 (Oda File: Screw Pump Influent 9-27-2018.oda -- Serial Number: OL45055972)
Average 8PPM
Month Transition Min 0PPM Max 97PPM (Use Screen Data Only)
Reset Zoom
Undo Zoom


City of Bismarck
GIS Map
Purple = Force mains
1600 N WASHINGTON ST
2.94 Detention time 30-in pipe
2.22 Detention time 24-in pipe
4.26 Detention time both
2.01 hr. Detention time 24-in pipe
2.92 hr. Detention time both

2018 Washington Lift
3.2 MGD. 50.6% of flow. 1-24 inch force main
12,600 ft. to WWTP. Detention time 2.2 hr.
30 inch + 24 inch to WWTP. 2.9 hr.
2 upstream force mains



Wachter Lift 2.9 MGD
24-inch 10,359 feet

2 hours detention time average. 2 upstream force mains.


MUNICH
BILLINGS
YORKSHIRE
BEDFORD
STRATFORD
DOVER
NOTTINGHAM
BUCKINGHAM
SHERWOOD
VICTORIA
IRVINE
CAMBRIDGE
OXFORD
CANTERBURY
SUSSEX
PICCADILLY
LONDON
ESSEX
MANCHESTER
WARWICK
WASHINGTON

Plant Upset Data

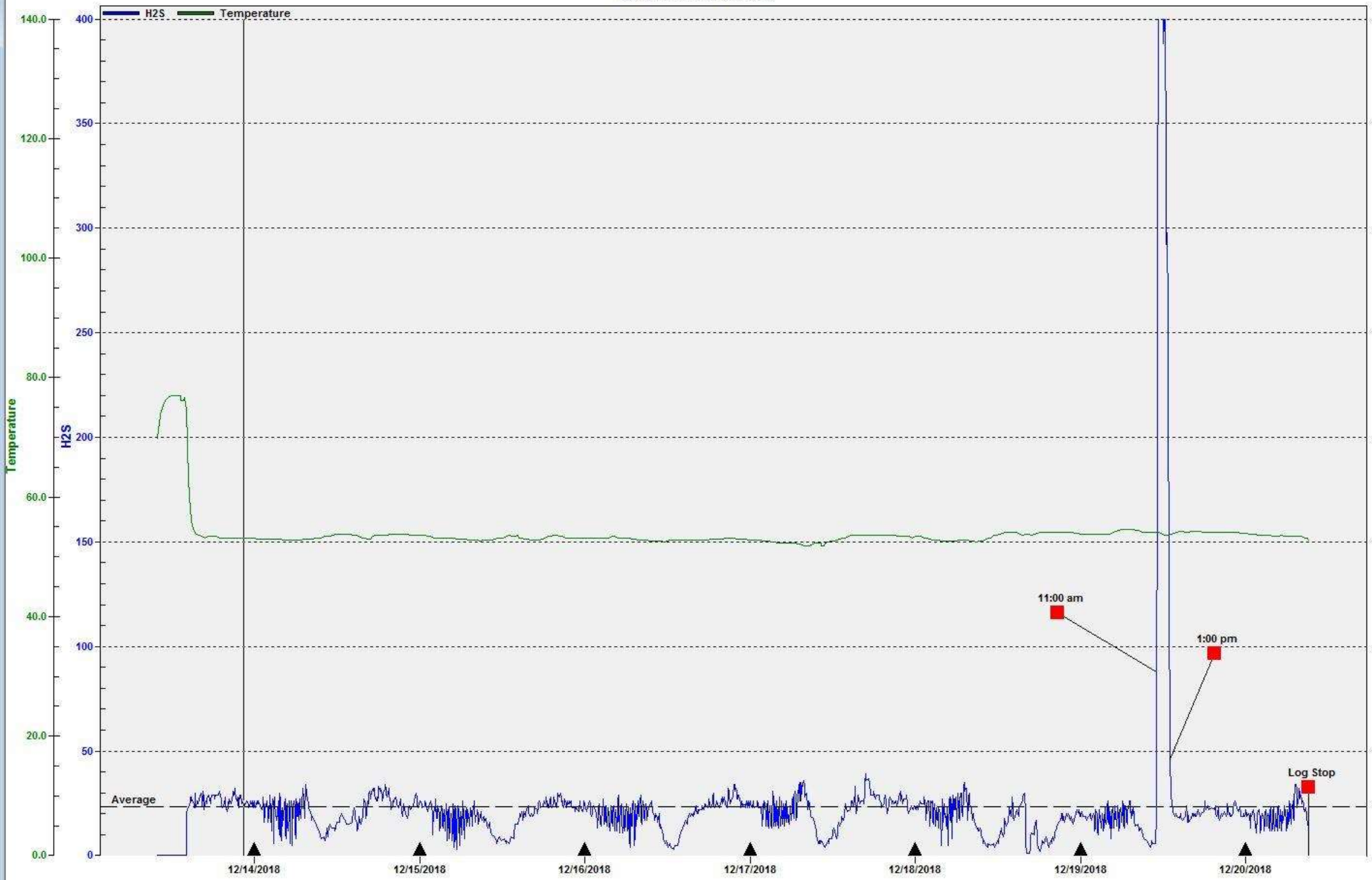
	Biorem		Screw Pump Infl.				
Date	H2S Avg.	H2S Peak	H2S Avg.	H2S Peak	Comment	Effl NH3	Effl CBOD
11/22/18	25	61	3	12		1.9	9
11/29/18	30	95	7	42		3.3	10
12/6/18	20	36	2	13		1.7	10
12/13/18	28	57	2	11	12/17/18, shut down TF3	2.5	10
12/20/18	23	**499**	4	**55**	12/19, rotate Washington after 2.5 mo.	9.9	15
12/28/18	29	55	3	25	12/26 Wachter after 2.5 mo., then daily	9.5	18
1/3/19	21	242	4	22	1/4/19 Stop rotating both force mains	**23.1**	**24**
1/10/19	21	69	4	18	for two months	28.4	20
1/17/19	14	32	5	19		27.6	16
1/24/19	20	36	4	18		15.4	14
2/1/19	14	43	5		Flushed TF 2, on 2/5/19	18.8	18
2/7/19	19	55	4	14	Flushed TF 1, on 2/13/19	10.2	14
2/14/19	14	30	9	36	TF 1 & 2 placed in series	**6.7**	21

When the dissolved H2S increases over 1 mg/L to the trickling filters the final effluent BOD and ammonia spike with a 6 – 7 week recovery.

C:\OdaStat-G\olgfiles\Biorem 12-20-2018_Session 1.olg

Biorem 12/13/18 - 12/20/2018

Biorem 12-20-2018: Session 1



Period Displayed: 12/13/2018 - 12/20/2018 (Oda File: Biorem 12-20-2018.oda -- Serial Number: Odalog Type L2-RTx 06811214 Instrument Range 0-0PPM)

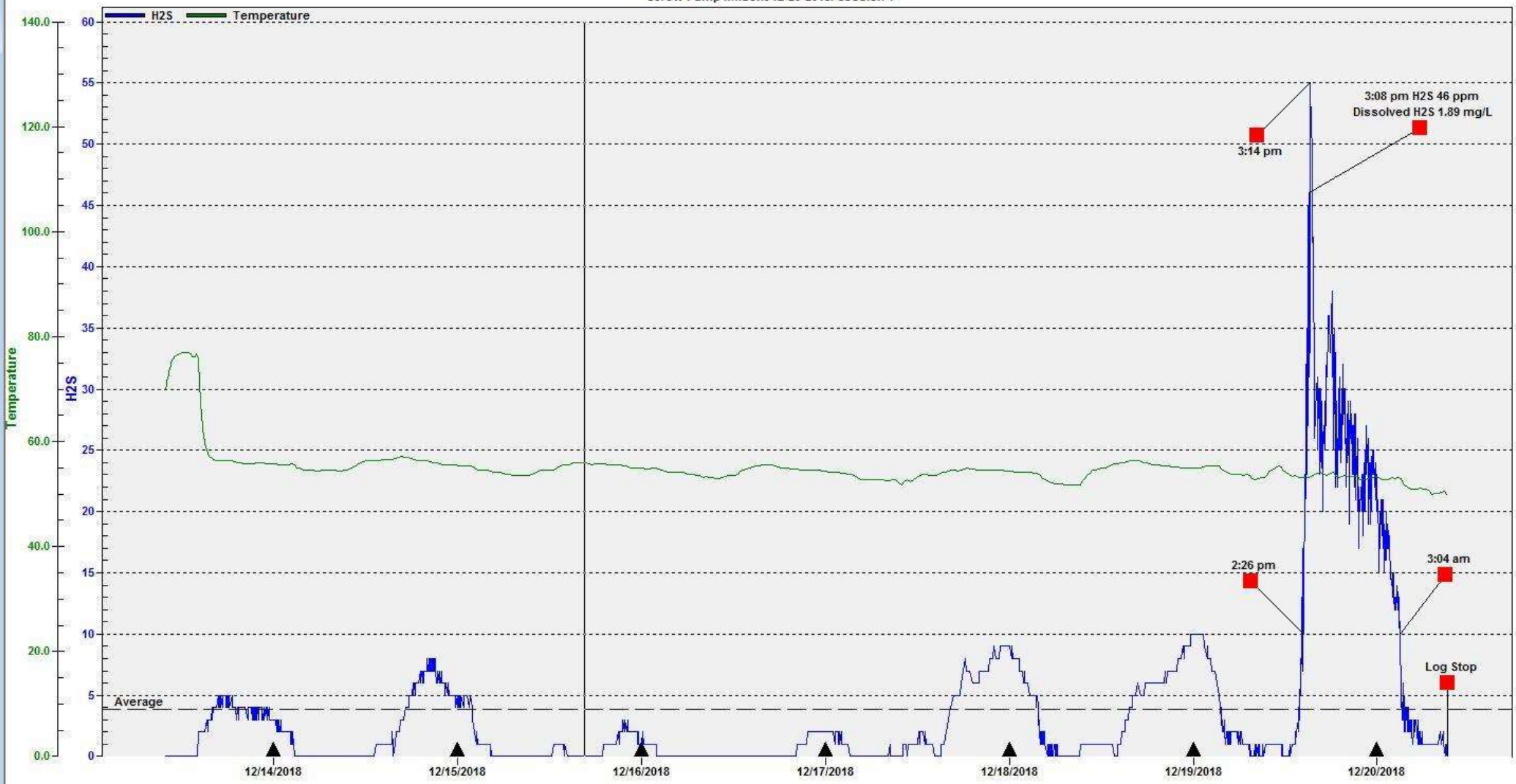
Average 23 | Day Transition Min 0 Max 499 (Use Screen Data Only)

Reset Zoom < > Undo Zoom

C:\OdaStat-G\olgfiles\Screw Pump Influent 12-20-2018_Session 1.olg

Screw Pump Influent 12/13/18 - 12/20/2018

Screw Pump Influent 12-20-2018: Session 1



Period Displayed: 12/13/2018 - 12/20/2018 (Oda File: Screw Pump Influent 12-20-2018.oda -- Serial Number: Odalog Type L2-RTx 06811211 Instrument Range 0-0PPM)

Average 4 | Day Transition Min 0 Max 55 (Use Screen Data Only)

Reset Zoom < > Undo Zoom

Current Strategy to Prevent H2S Toxicity

When rotating the Washington or Wachter force main

- Divert the wastewater through flow equalization for dilution, mixing and aeration.
- Max the ferric chloride dose during the two - three hours of elevated H2S.

Sampling Pretreatment Influent


Sampling Pretreatment Effluent

Table 7-2. Dosage Information from Liquid Phase Odor Control Methods.

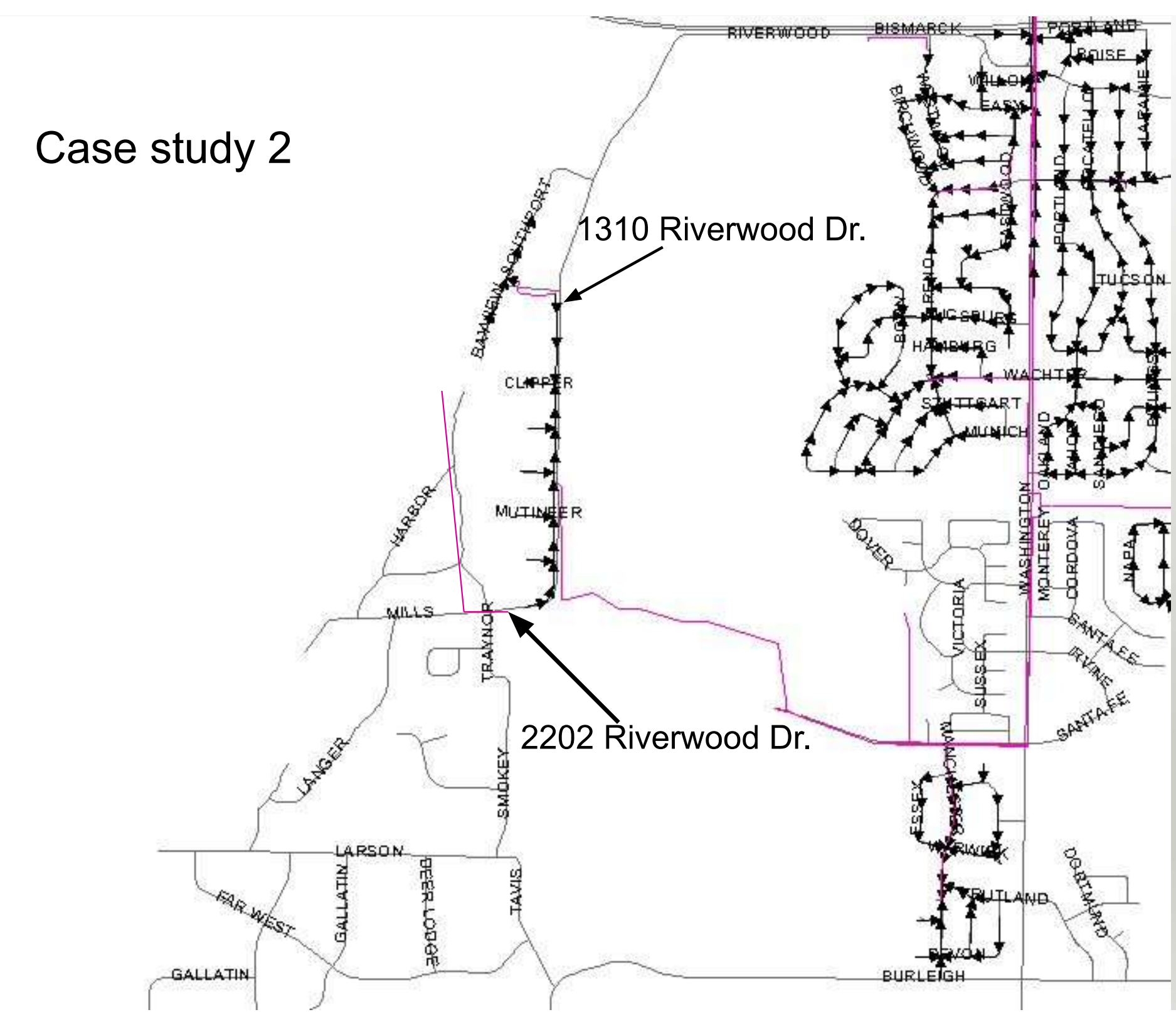
Chemical	Concentration (% by weight)	Solution Density (lb/gal.)	Dose (lb/lb of Sulfide Removed)	
			Low	High
Pure O_2	95	gas	Not directly comparable to other chemicals	
Cl_2 gas	100	gas	4	15
NaOCl	15	9.7	10	15
H_2O_2	50	10.0	1	4
$KMnO_4$	5	8.7	6	7
$NaMnO_4$	20	9.8	7	8
$FeCl_2$	30	10.0	4	12
$FeSO_4$	6	10.0	5	14
$FeCl_3$	40	10.8	3	7
$Ca(NO_3)_2$	60	12.1	4	15
NaOH	50	11.4	Doses must be compared to other methods on a case-by-case basis as they are not directly related to sulfide concentration alone	
$Mg(OH)_2$	63	13.3		

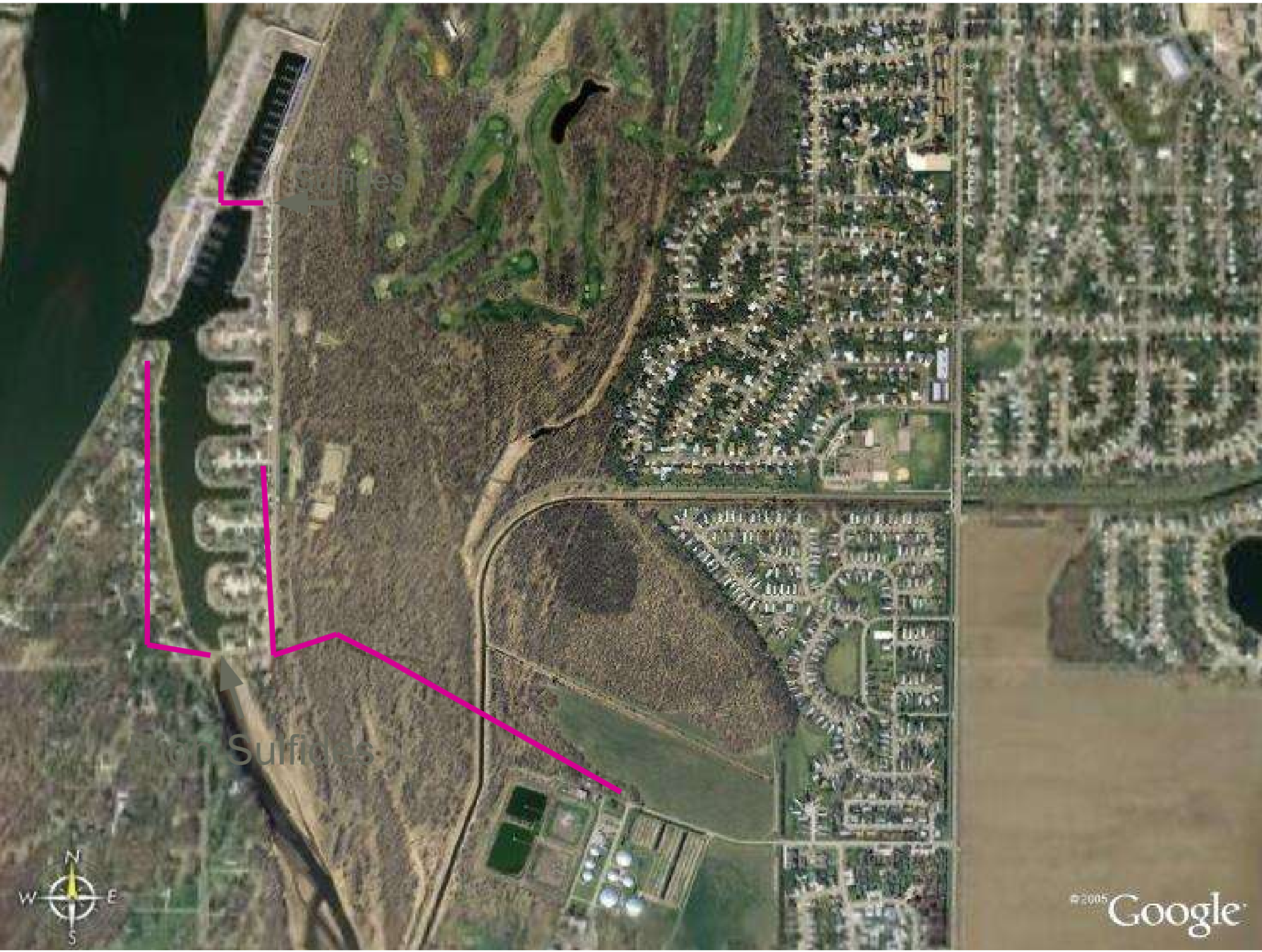
Minimization of Odors and Corrosion in Collection Systems Phase 1 WERF 2007

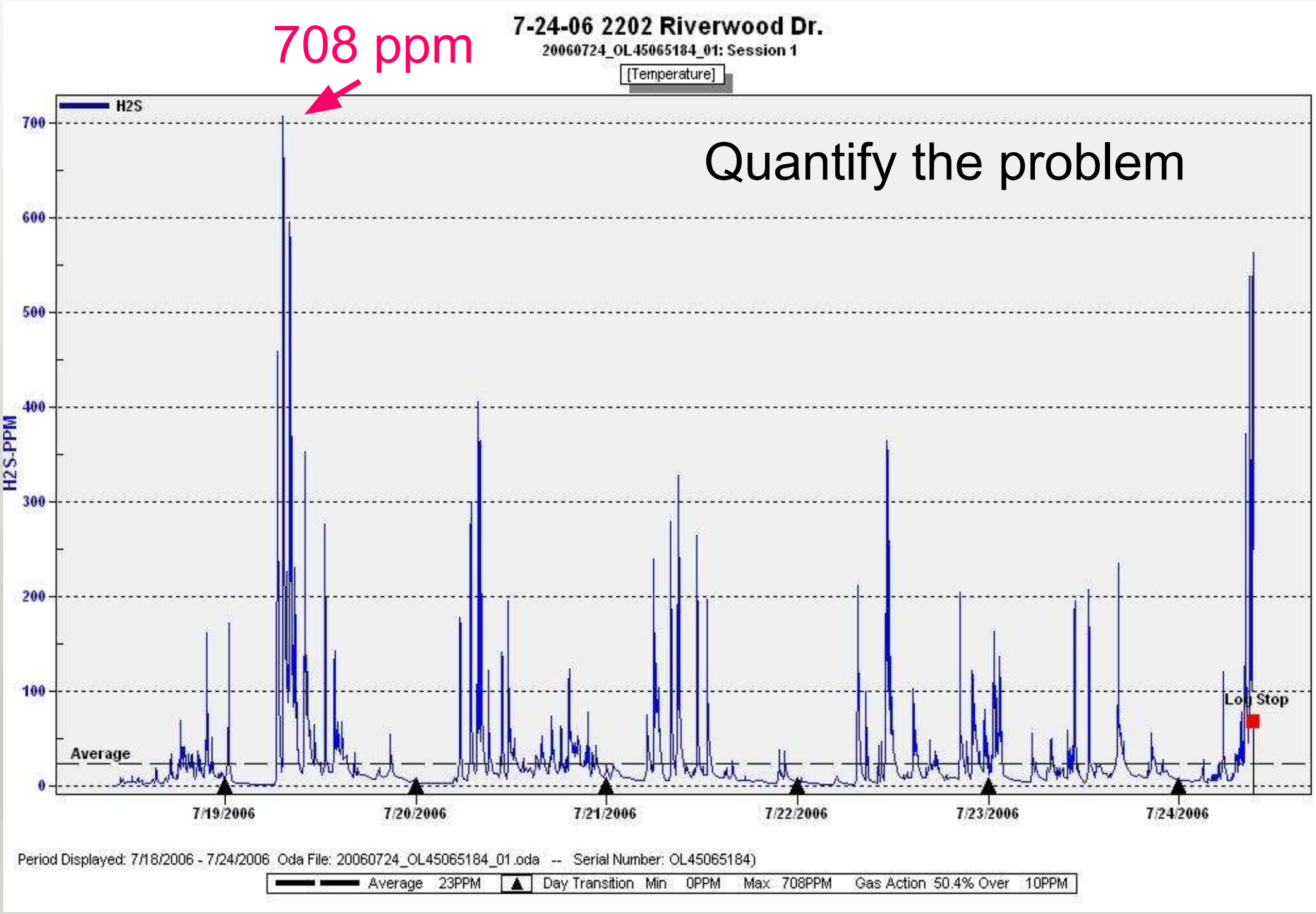
Private 3-mile force main case study 1

Date	Dissolved H2S mg/l	Air H2S mg/l	Comments
9/22/1999		53	No Chemical Addition
6/8/2000	35	<2	No Treatment
8/11/2000	**46**		No Treatment
10/16/2000	45		
10/19/2000	0		Adding 4 gallons 5.25% bleach/day
11/21/2000	2.5		
1/11/2001	9.5		Adding KMnO4
4/30/2001	15		Adding KMnO4
5/22/2001	0.65		Adding 3 gallons 5.25% bleach/day
6/10/2002	0.15		
7/26/2002	0.1		Adding 3 gallons azone/day
11/7/2002	0.1		
4/28/2003	0.05		

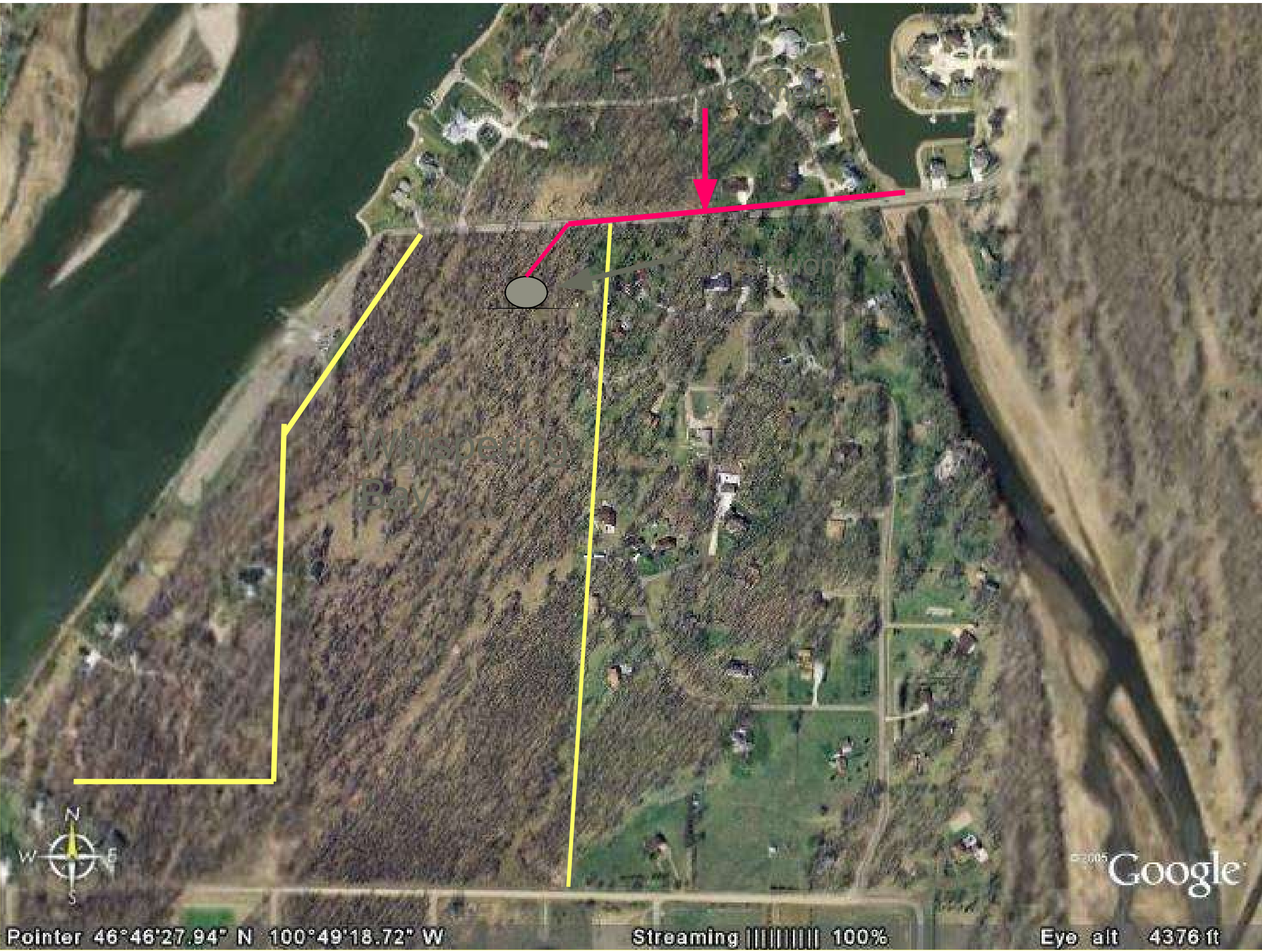
Case study 2


1310 Riverwood Dr.
2202 Riverwood Dr.
RIVERWOOD
BISMARCK
PORTLAND
BOISE
BAXWIN
SOUTHPORT
CLIPPER
MUTINEER
HARBOR
MILLS
TRAYNOR
LANGER
SMOKEY
LARSON
FAR WEST
GALLATIN
BEAR LODGE
TAWIS
BURLEIGH
RUTLAND
DORTMUND
ESSEX
VICTORIA
SUSSEX
DOVER
WASHINGTON
MONTEREY
CORDOVA
NAPA
SANTA FE
IRVINE
TUCSON
OAKLAND
SAN DIEGO
RENO
HAMBURG
WACHTER
STUTTGART
MUNICH


Sulfides
Sulfides
N
W
E
S
©2005 Google


708 ppm
7-24-06 2202 Riverwood Dr.
20060724_OL45065184_01: Session 1
[Temperature]
Quantify the problem
H2S
H2S-PPM
700
600
500
400
300
200
100
0
Average
Log Stop
7/19/2006
7/20/2006
7/21/2006
7/22/2006
7/23/2006
7/24/2006
Period Displayed: 7/18/2006 - 7/24/2006 Oda File: 20060724_OL45065184_01.oda -- Serial Number: OL45065184)
Average 23PPM
Day Transition Min 0PPM Max 708PPM Gas Action 50.4% Over 10PPM


Homes with
grinder pumps
Red = Force mains
N
W
E
S
©2005 Google


Whispering
Bay
N
W
E
S
Pointer 46°46'27.94" N 100°49'18.72" W
Streaming 100%
Eye alt 4376 ft
Google

Pilot Testing Southport Force Main

	7-day average Plant Influent Dissolved H2S mg/L	Southport Infl./Whispering Bay, Force main dissolved H2S at WWTP				Southport mg/L H2S
Date	H2S Infl. 7day avg.	H2S Avg.	H2S Peak	Chem	Dose GPD	H2S diss
5/18/17	5.8					35.8
6/8/17	5.2					42.0
6/14/17	6.0			Azone	2	26.0
6/22/17	6.0	18	138	Azone	4	26.7
6/29/17	3.5			Azone	6	28.5
7/6/17	5.5			Azone	8	27.4
7/13/17	6.9			Azone	8	7.3
7/20/17	6.4			Azone	8	12.0
7/26/17	5.0			Azone	4	2.7
8/3/17	6.4			Azone	8	2.0
8/9/17	6.2			Azone	8	1.3
8/17/17	6.4			CaNO3	6	3.9
8/31/17	8.0			CaNO3	4	0.1
9/7/17	4.9			CaNO3	2	1.3
9/14/17	5.5			CaNO3	2	2.9
9/21/17	6.4			CaNO3	2	4.7
9/28/17	8.1			CaNO3	2	2.9
10/5/17	8.0			CaNO3	2	5.2

Pilot Testing Southport Force Main

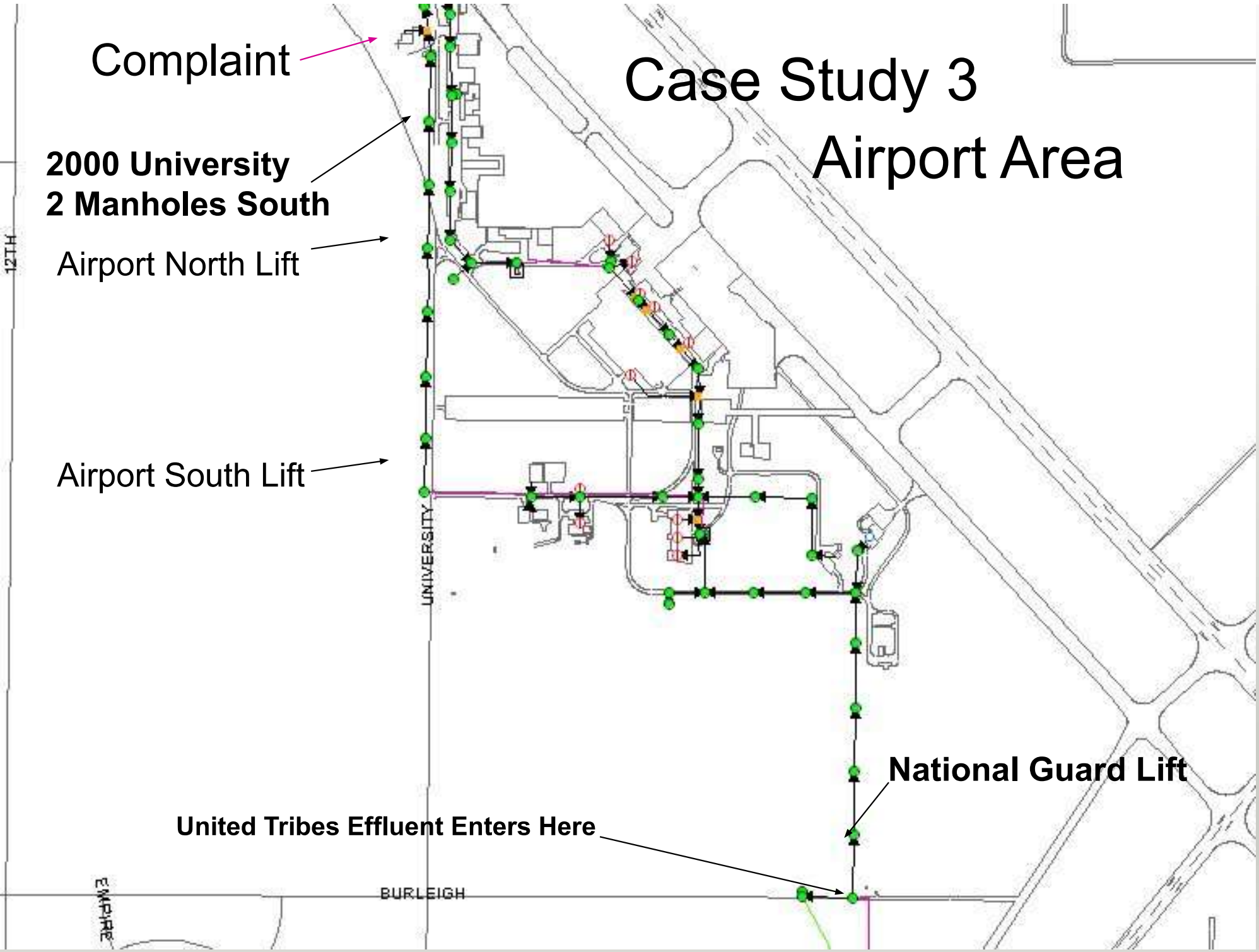
	7-day average Plant Influent Dissolved H2S mg/L	Southport Infl./Whispering Bay, Force main dissolved H2S at WWTP				Southport mg/L H2S
5/31/18	2.8	2	21	Water	31.6k	1.5
6/7/18	5.3	2	35	Water	31.6k	1.2
6/14/18	4.1	2	37	Water	31.6k	1.8
6/21/18	4.0	1	14	Water	31.6k	5.1
6/28/18	4.8	3	28	Water	31.6k	7.5
7/9/18	2.9	9	299	Water	31.6k	6.4
7/19/18	4.6	3	39	Water	5gal	1.4
7/26/18	3.6	3	63	Water	31.6k	4.2
8/2/18	6.4	2	37	Water	31.6k	14.0
8/9/18	6.4	2	44	Water	31.6k	3.3
8/16/18	5.9	2	40	Water	31.6k	3.8
8/23/18	6.7	1	20	Water	31.6k	10.7
8/30/18	6.3	1	40	Water	31.6k	3.7
9/6/18	6.7	1	27	Water	31.6k	4.6
9/13/18	6.1	1	24	NaOH	5gal	0.2
9/21/18	5.7	No	Data	Water	31.6k	0.4
9/27/1PI8	6.0	0	58	Water	Off	0.2

Pilot Testing Southport Force Main

	7-day average Plant Influent Dissolved H2S mg/L	Southport Infl./Whispering Bay, Force main dissolved H2S at WWTP				Southport mg/L H2S
5/9/19	2.7			Water		1.7
5/23/19	3.4			NaOH		2.6
5/30/19	2.2			Water		0.1
6/6/19	2.8			Water		0.2
6/13/19	2.6			Water		4.7
6/20/19	3.8			Water		1.0
6/27/19	2.6			Water		1.3
7/11/19	3.1			Water		1.2
7/18/19	5.4			Water		1.4
7/25/19	4.7			Caustic		0.6
8/1/19	3.0			5gal		0.2
8/8/19	3.5			Water		1.6
8/15/19	3.3			Water		4.6
8/22/19	4.5			Water		0.2
8/29/19	5.8	1	23	43200		2.3
9/5/19	4.8	0	13	Bacteria		9.6
9/12/19	2.9	2	25	Bacteria		12.1
9/19/19	2.7	1	37	Bacteria		23.7
9/27/19	3.1	1	30	Bacteria		18.0
10/3/19	4.3			off		24.9

Riverwood Drive Solutions

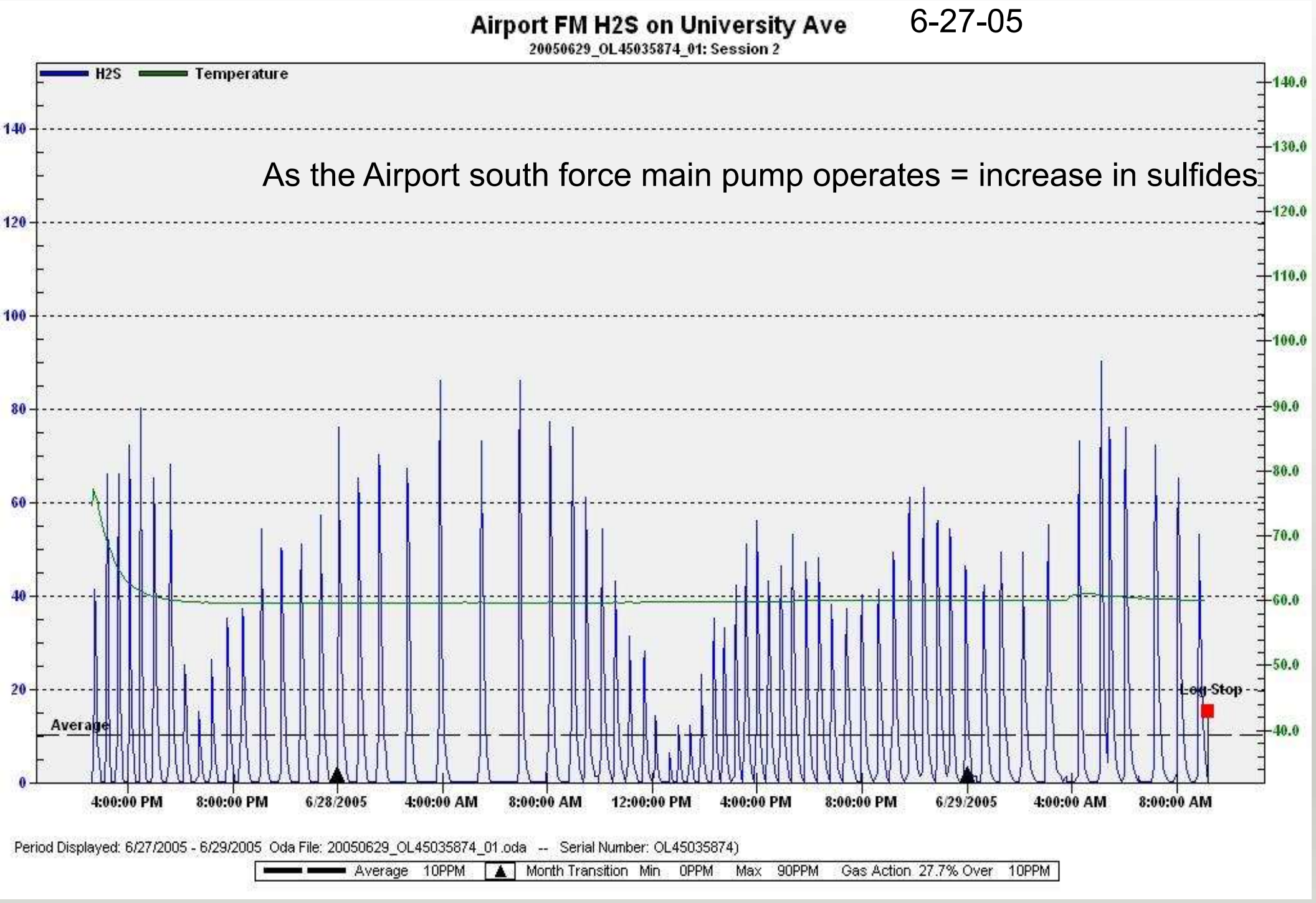
- Increase pumping frequency of private lift station, lower pump set points
- Reduce holding time of wastewater in private holding tanks with grinder pumps
- Increase water flow through Whispering Bay during summer months


Complaint
Case Study 3
Airport Area
2000 University
2 Manholes South
Airport North Lift
Airport South Lift
National Guard Lift
United Tribes Effluent Enters Here
UNIVERSITY
BURLEIGH
12TH
EMPIRE


Complaint
2000 University
2 Manholes South
Airport North Lift
Airport South Lift
National Guard Lift
United Tribes Effluent
12TH
UNIVERSITY
BURLEIGH
EMPIRE

Airport Area Sulfide Testing Data

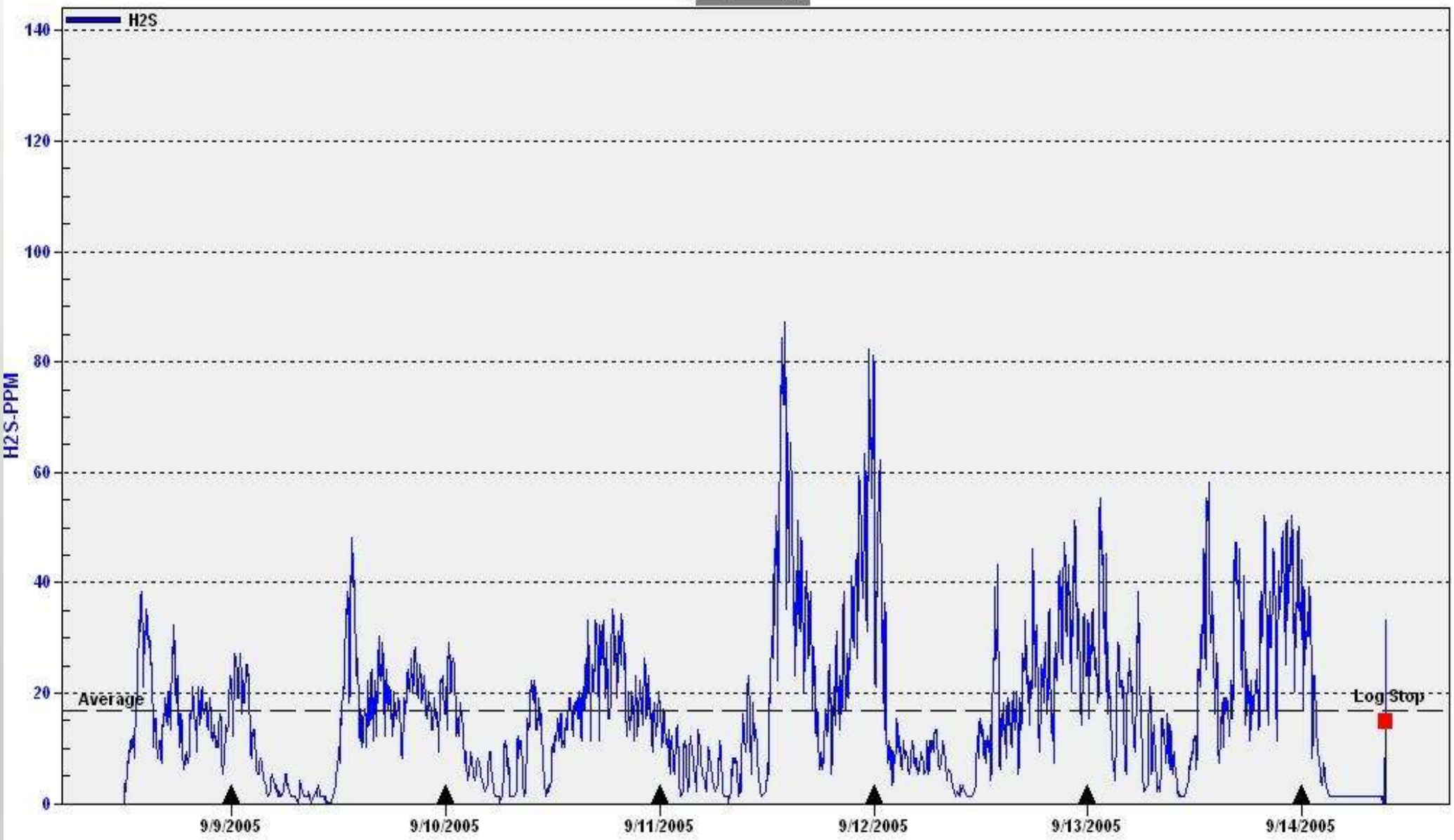
Date	Time	Dissolved Sulfides mg/l	Air Sulfides mg/l	pH	Sample Location	
6/14/05	10 a.m.		**45, 39**		East	Vent from 2000 University Drive
6/14/05	10 a.m.		29		West	Vent
6/16/05	11 a.m.		1, 4		Gate 100	Manhole 3710
6/16/05			2		Manhole	1 S 2000 University
6/16/05			1		Manhole	2 S 2000 University
6/17/05			8		Manhole	1 NW 2000 University
6/17/05	2:05 PM		10		Manhole	2 NW 2000 University
6/17/05			11		Manhole	3 NW 2000 University
6/17/05	2:15 PM		5		Manhole	4 NW 2000 University
6/17/05	2:25 PM		1		Manhole	5 NW 2000 University
6/17/05	2:29 PM		0		Manhole	6 NW 2000 University
6/17/05			33, 26		Manhole	1 S 2000 University
6/17/05	3:10 PM		7, 1		Manhole	3 S 2000 University
6/17/05	3:18 PM		0		Gate 100	Manhole 3710
6/20/05	3:25 PM	1.0		7.8	Manhole	2 S 2000 University
6/20/05	3:30 PM	**6.25**		7.88	Manhole	2 S 2000 University
6/27/05	3:20 PM		59		Manhole	2 NW 2000 University
6/27/05	15:00				Manhole	First manhole upstream of Airport Maintenance Building Lift added 3 gallons of 5% bleach
6/28/05	9:00				Manhole	First manhole upstream of Airport Maintenance Building Lift added 3 gallons of 5% bleach
7/5/05	13:00	1.7		7.8	Manhole	2 S 2000 University


Airport FM H2S on University Ave
6-27-05
20050629_OL45035874_01: Session 2
H2S
Temperature
As the Airport south force main pump operates = increase in sulfides
Average
Log Stop
4:00:00 PM
8:00:00 PM
6/28/2005
4:00:00 AM
8:00:00 AM
12:00:00 PM
4:00:00 PM
8:00:00 PM
6/29/2005
4:00:00 AM
8:00:00 AM
Period Displayed: 6/27/2005 - 6/29/2005 Oda File: 20050629_OL45035874_01.oda -- Serial Number: OL45035874)
Average 10PPM
Month Transition Min 0PPM Max 90PPM Gas Action 27.7% Over 10PPM

2000 University 2 Manholes South 9-14-05

20050914_OL45055972_01: Session 1

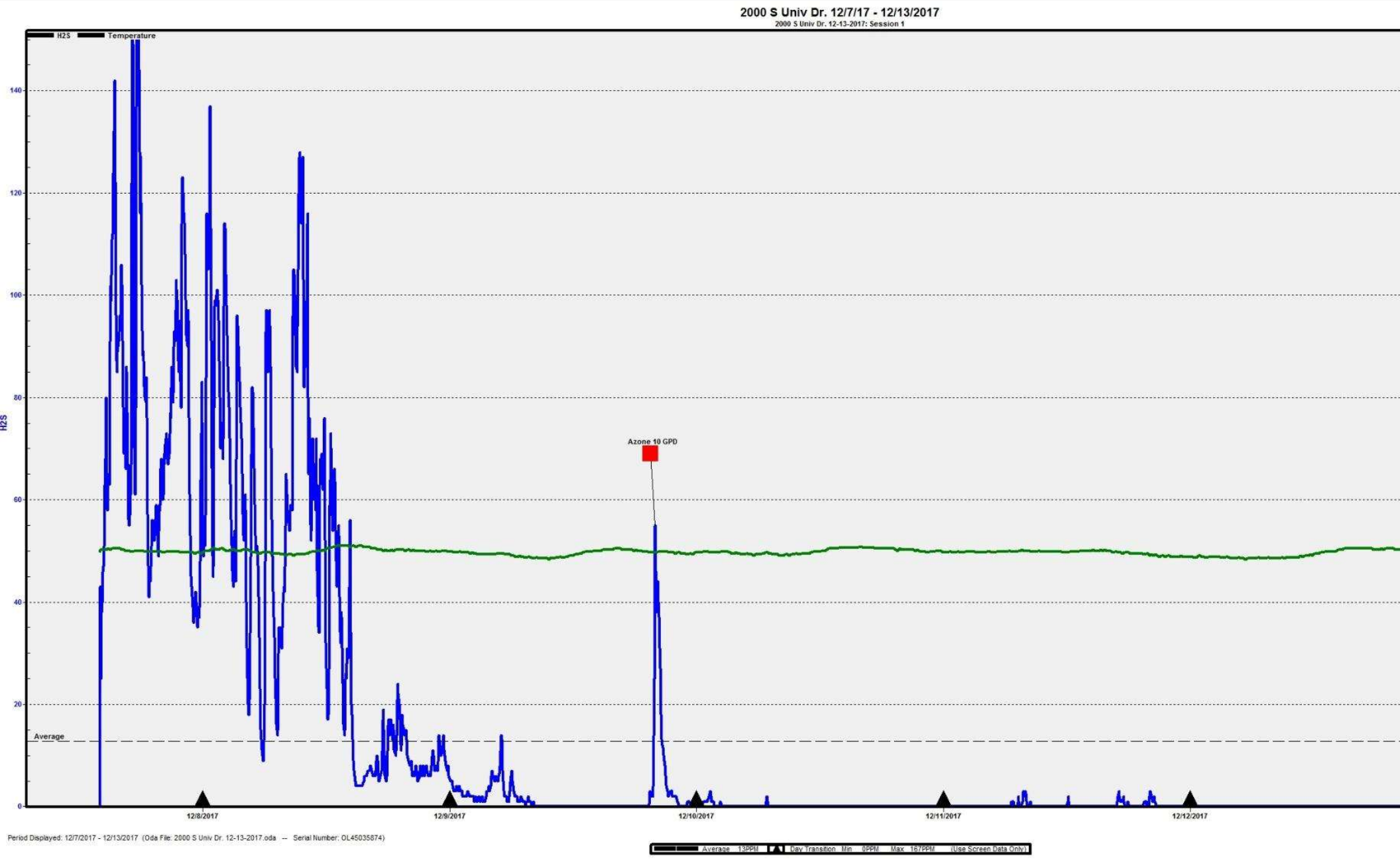
[Temperature]



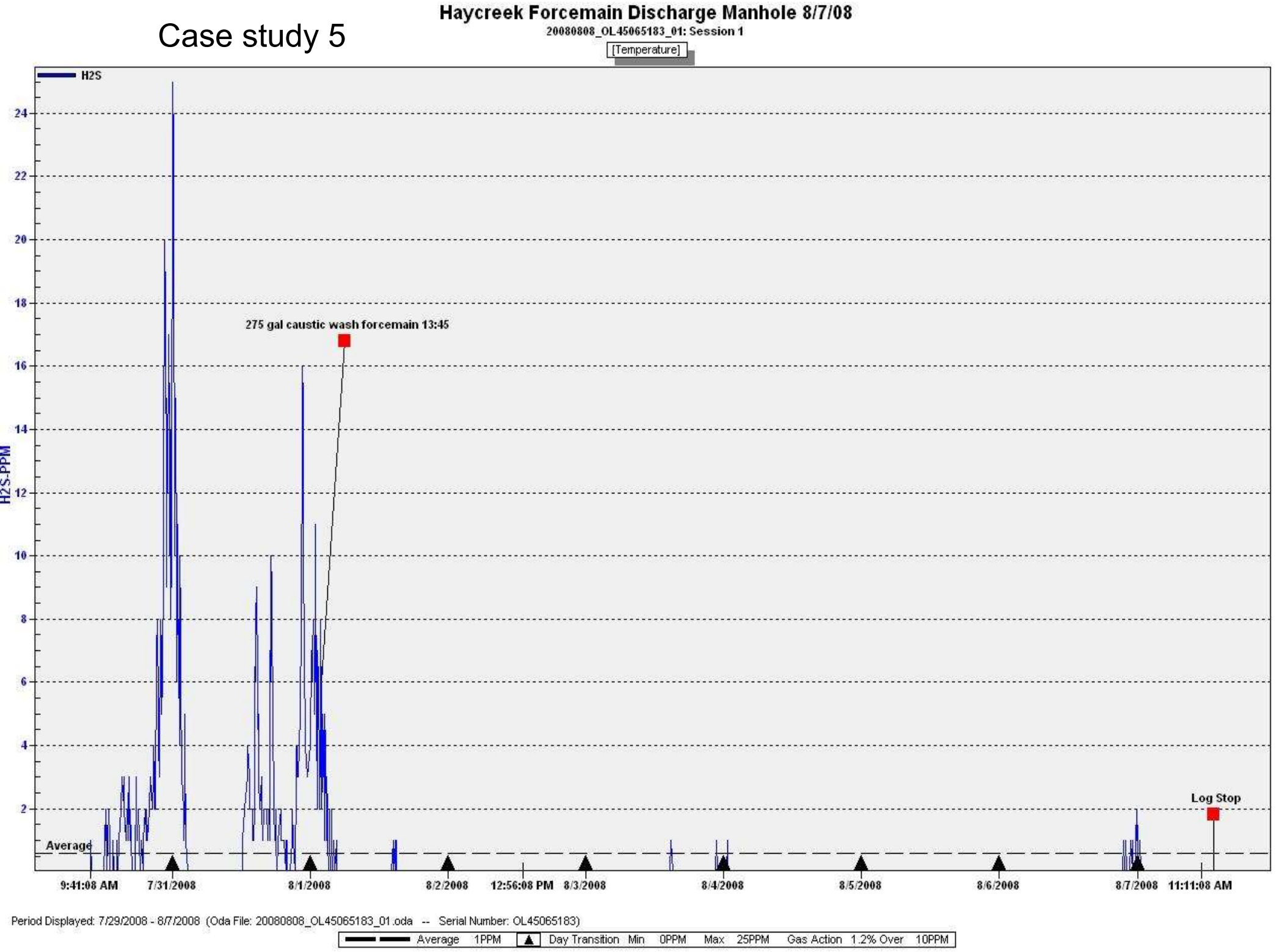
Period Displayed: 9/8/2005 - 9/14/2005 Oda File: 20050914_OL45055972_01.oda -- Serial Number: OL45055972)

Average 17PPM | Month Transition | Min 0PPM | Max 87PPM | Gas Action 61.5% Over 10PPM

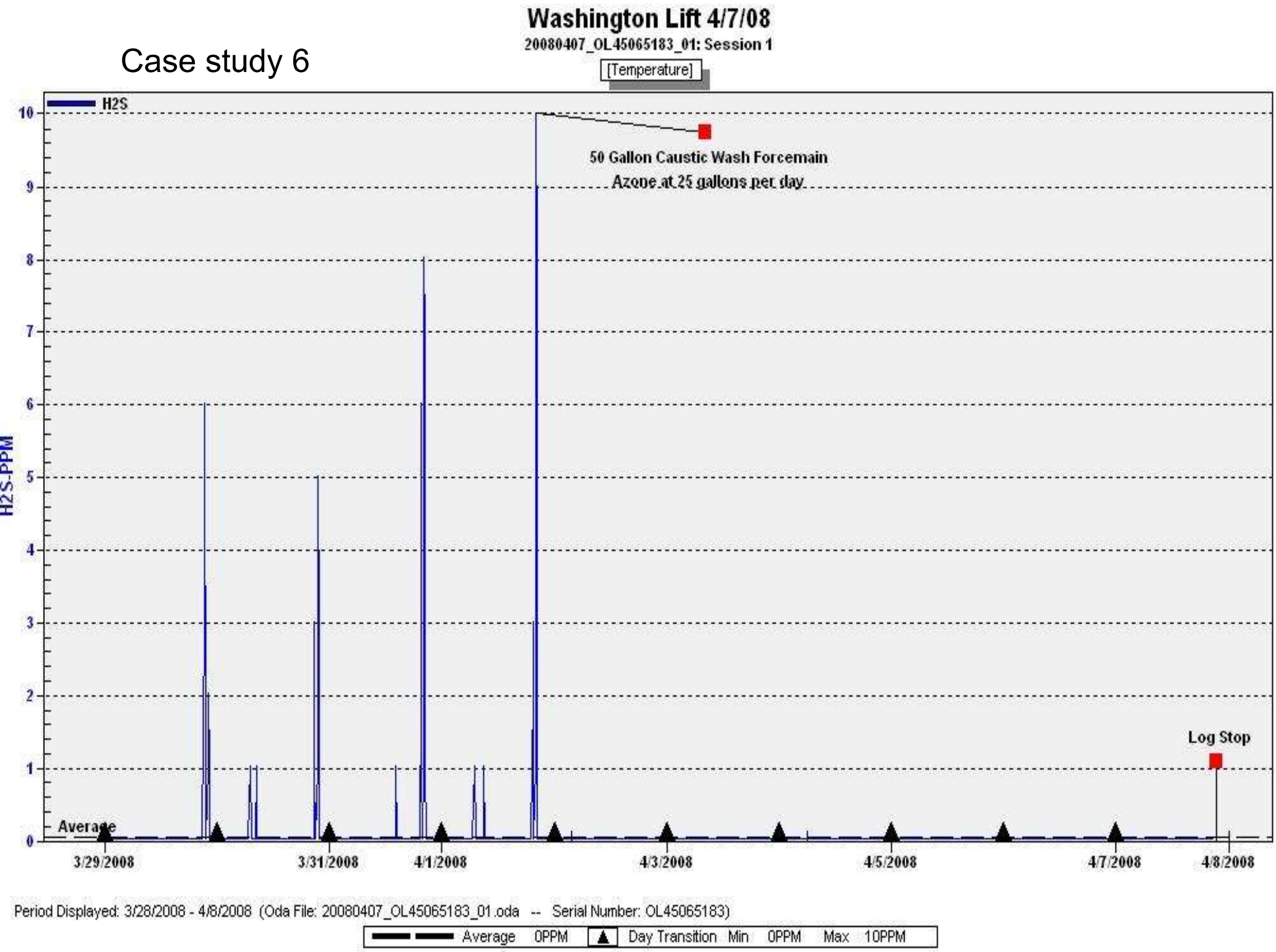

DANGER
SODIUM
HYPOCHLORITE
27 1:54PM


2000 S Univ Dr. 12/7/17 - 12/13/2017
2000 S Univ Dr. 12-13-2017: Session 1
H2S
Temperature
140
120
100
80
60
40
20
0
H2S
Azone 10 GPD
Average
12/8/2017
12/9/2017
12/10/2017
12/11/2017
12/12/2017
Period Displayed: 12/7/2017 - 12/13/2017 (Oda File: 2000 S Univ Dr. 12-13-2017.oda -- Serial Number: OL45035874)
Average 13PPM
Day Transition Min 0PPM Max 167PPM (Use Screen Data Only)

Case study 5

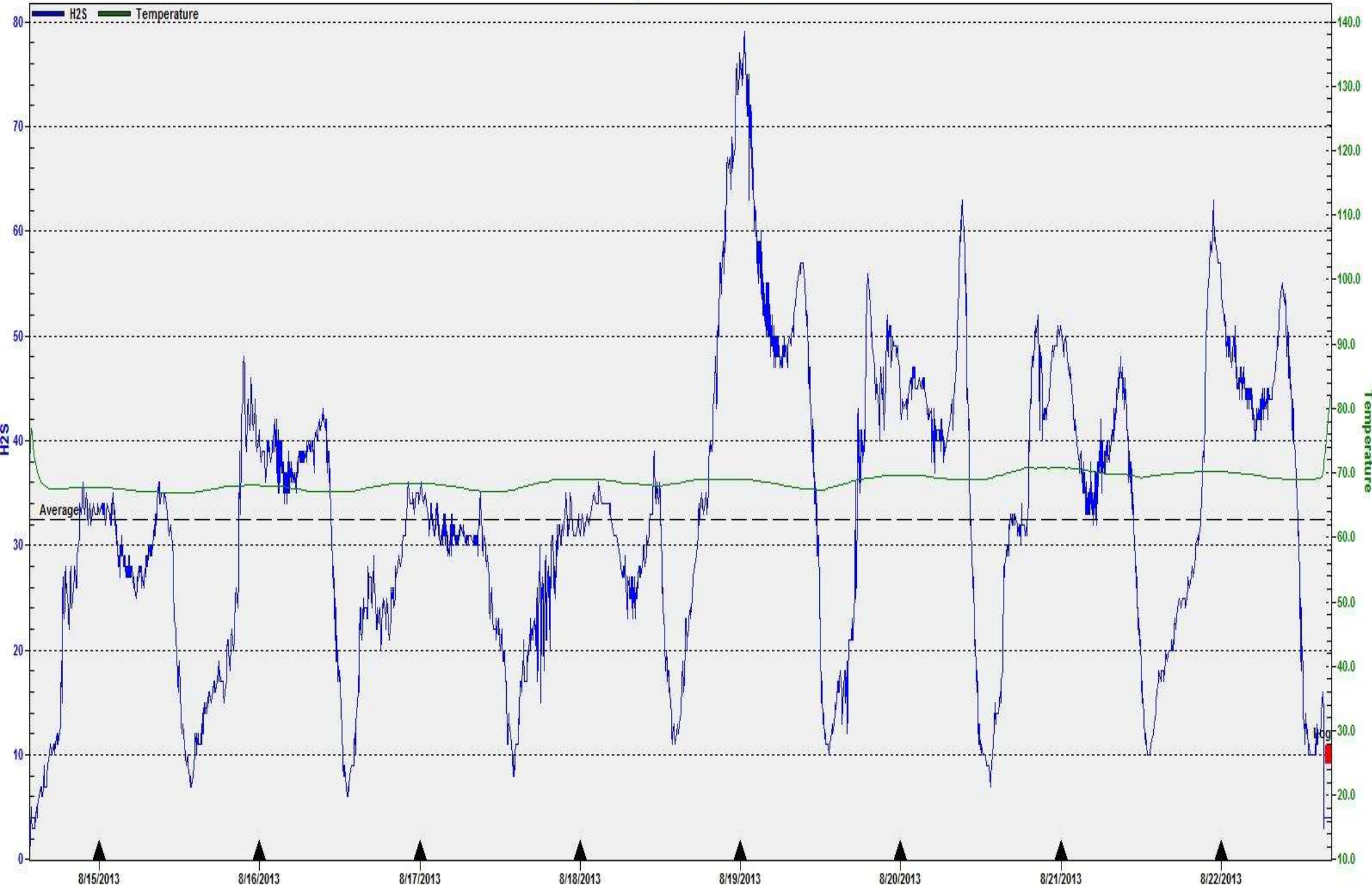

Haycreek Forcemain Discharge Manhole 8/7/08
20080808_OL45065183_01: Session 1
[Temperature]
H2S
H2S-PPM
24
22
20
18
16
14
12
10
8
6
4
2
275 gal caustic wash forcemain 13:45
Log Stop
Average
9:41:08 AM
7/31/2008
8/1/2008
8/2/2008
12:56:08 PM
8/3/2008
8/4/2008
8/5/2008
8/6/2008
8/7/2008
11:11:08 AM
Period Displayed: 7/29/2008 - 8/7/2008 (Oda File: 20080808_OL45065183_01.oda -- Serial Number: OL45065183)
Average 1PPM
Day Transition Min 0PPM Max 25PPM
Gas Action 1.2% Over 10PPM

Case study 6


Washington Lift 4/7/08
20080407_OL45065183_01: Session 1
[Temperature]
H2S
50 Gallon Caustic Wash Forcemain
Azone at 25 gallons per day
H2S-PPM
10
9
8
7
6
5
4
3
2
1
0
Log Stop
Average
3/29/2008
3/31/2008
4/1/2008
4/3/2008
4/5/2008
4/7/2008
4/8/2008
Period Displayed: 3/28/2008 - 4/8/2008 (Oda File: 20080407_OL45065183_01.oda -- Serial Number: OL45065183)
Average 0PPM
Day Transition Min 0PPM Max 10PPM

Washington Lift 8/15 - 8/22/2013

Washington Lift 8-22-2013: Session 1



Period Displayed: 8/14/2013 - 8/22/2013 (Oda File: Washington Lift 8-22-2013.oda -- Serial Number: OL45055972)

Average 32PPM | Month Transition | Min 0PPM | Max 79PPM | (Use Screen Data Only)

Washington Lift 9/9 - 9/16/13

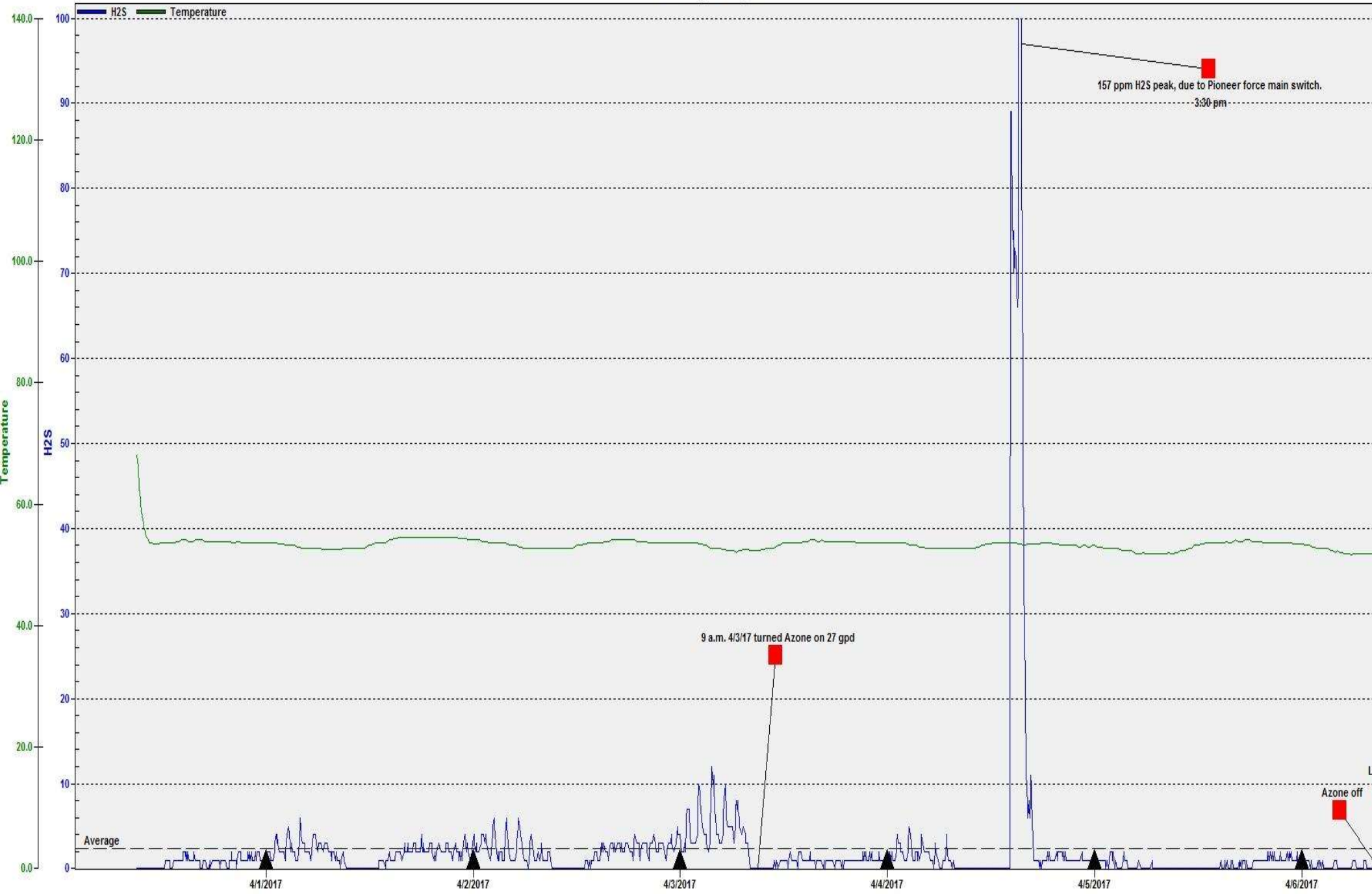
Washington Lift 9-16-2013: Session 1

Period Displayed: 9/9/2013 - 9/16/2013 (Oda File: Washington Lift 9-16-2013.oda -- Serial Number: OL45025783)

Average 6PPM | Month Transition Min 0PPM Max 41PPM (Use Screen Data Only) (Apply Sensor Decay)

Washington Lift Diversion Vault 4/1/17 - 4/6/2017

20170406_02709695_01: Session 1



Period Displayed: 3/31/2017 - 4/6/2017 (Oda File: 20170406_02709695_01.oda -- Serial Number: Odalog Type L2-RTx 02709695 Instrument Range 0-0PPM)

Average 2 | Month Transition Min 0 Max 157 (Use Screen Data Only)

Jar Testing Ferric Chloride

How Did We Get Here?

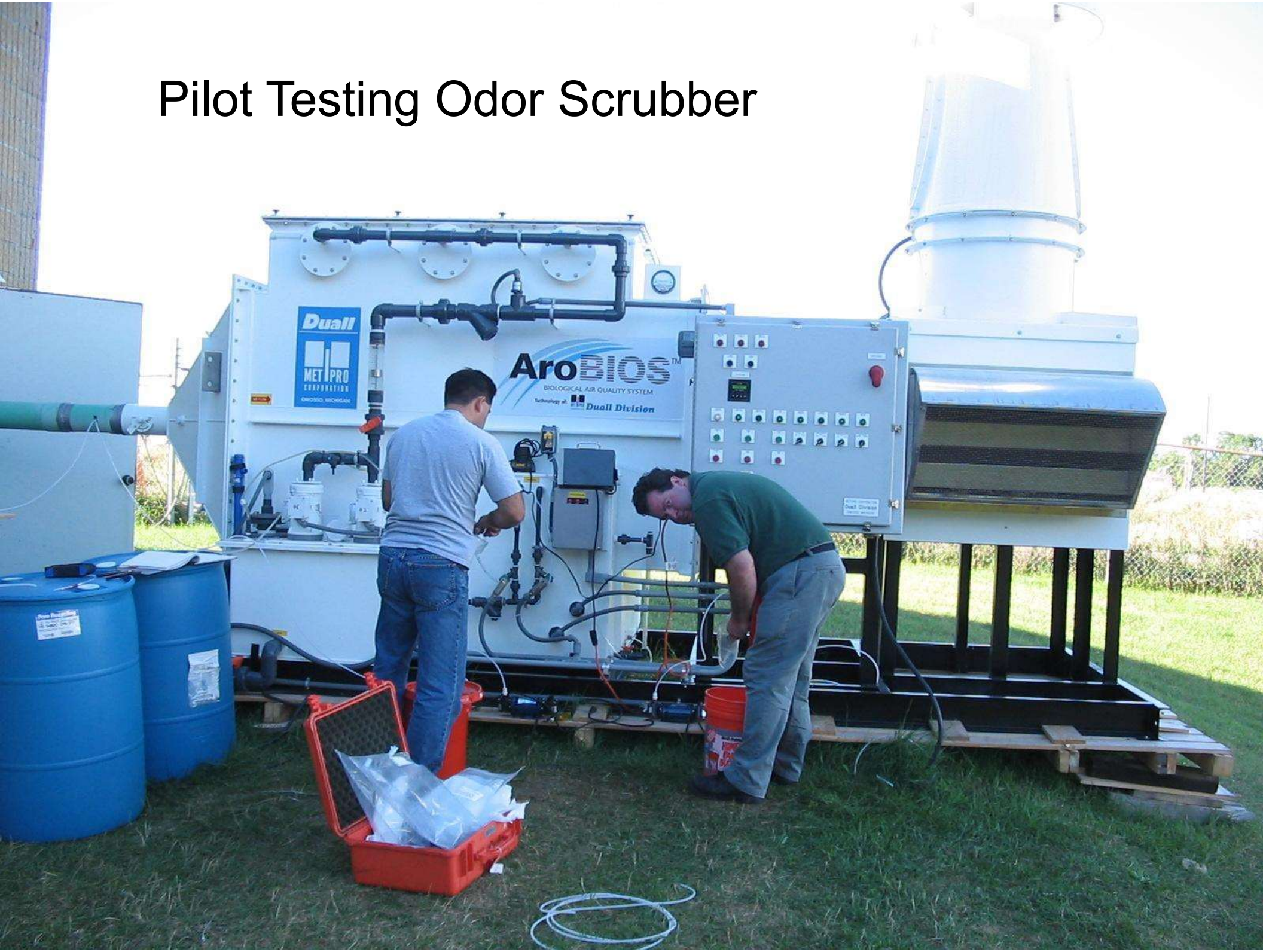
- Historical information
- Investigation of original assumptions
- Jar/bench testing
- Allocation of resources
- Pilot testing
- Follow up monitoring

Air Stream Odor Removal

Air Treatment Alternatives, from WEF MOP-22, 1995

	Frequency of use	Cost Factor	Advantage	Disadvantage
Packed-Tower Wet Scrubber	High	Moderate Capital and O&M	Effective and reliable	Chemical consumption No VOC removal
Fine Mist wet scrubber	Medium	High Capital Cost that tower	Low chemical consumption VOC removal	Large vessel, need to soften scrubber water
Carbon	High	Depends or removal freq	No moving parts	Dilute H2S only, high cost w/ high VOC
Biofilter	Medium	Low Capital and O&M cost	Simple, VOC effective	Media replacement, moisture monitoring
Thermal Oxidizer	Low	High Capital & Energy Cost	Effective, VOC removal	Economical for high H2S, difficult to treat
Activated Sludge	Low	Economical	Simple, low O&M, effective	Blower corrosion, not for high H2S
Masking agents	High	Dependent on usage	Low capital, for sporadic odors	Only mask, no VOC removal

Pilot Testing Odor Scrubber

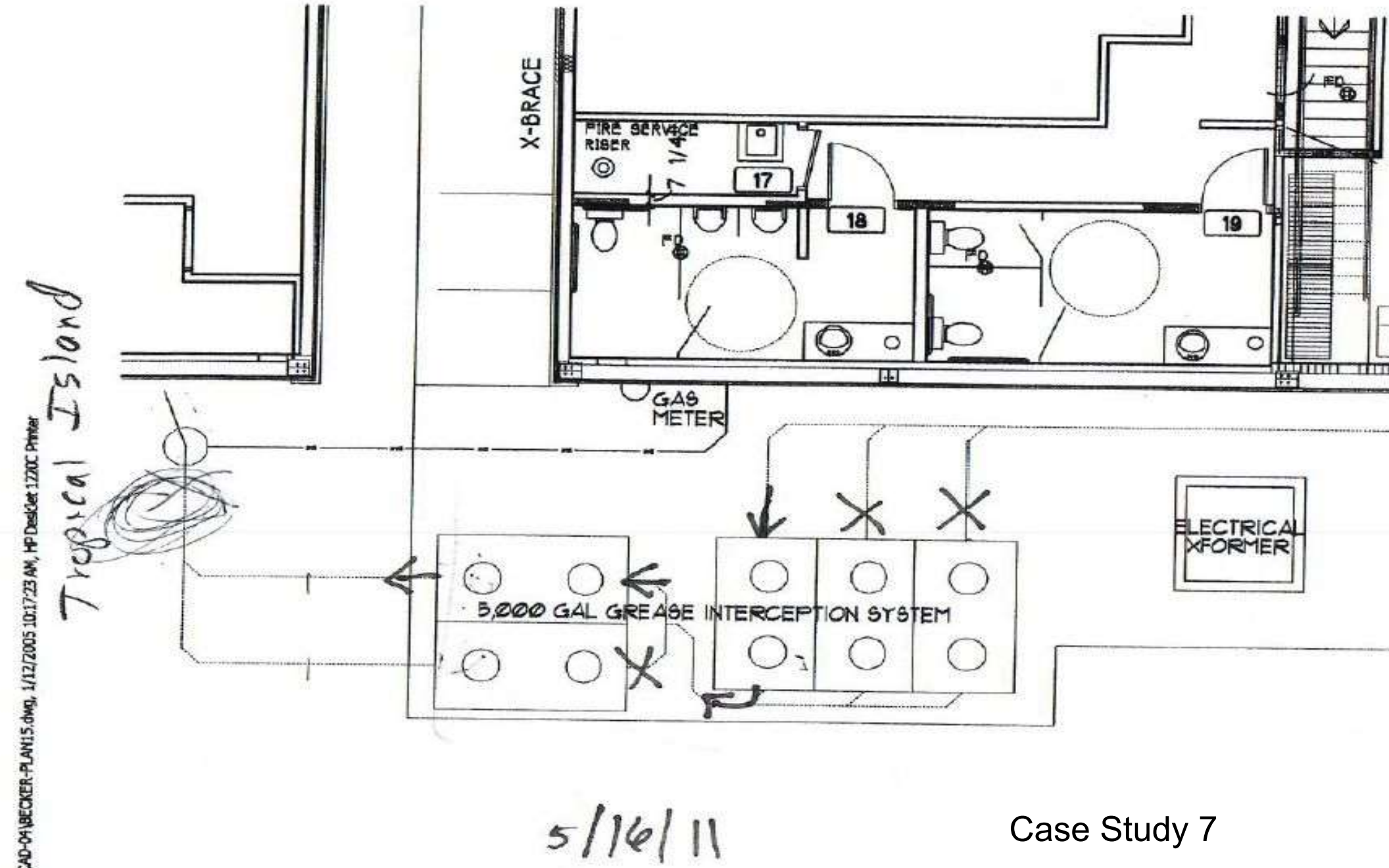


Pilot Testing a Biofilter

Filtration Removal Options for Low Air Flow

Do y'all remember, before the internet, that people thought the cause of stupidity was the lack of access to information?
Yeah. It wasn't that.

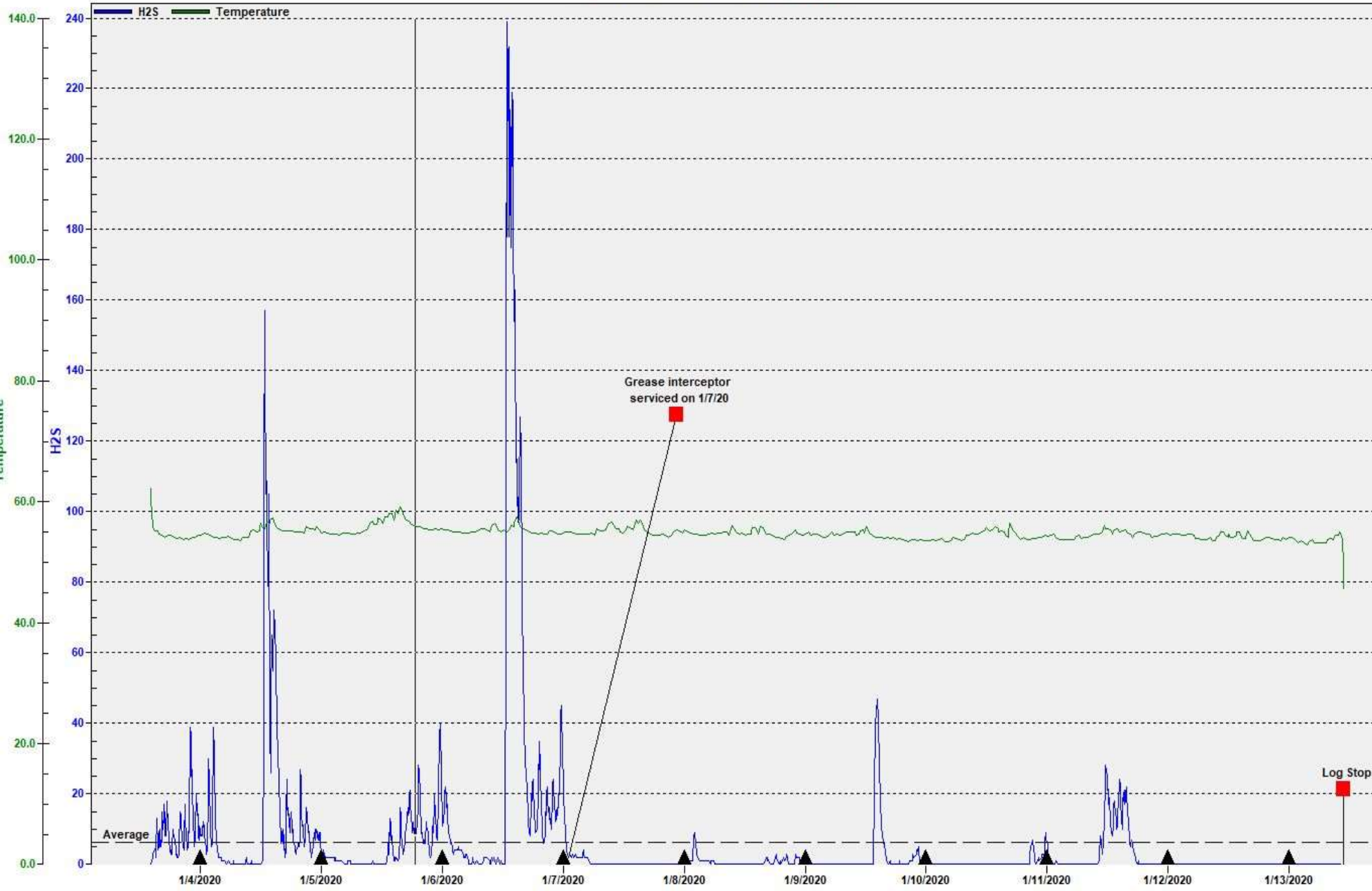

You play any dangerous sports?
I sometimes disagree with my wife


X-BRACE
FIRE SERVICE RISER
17
18
19
FD
GAS METER
ELECTRICAL XFORMER
5,000 GAL GREASE INTERCEPTION SYSTEM
Tropical Island
D:\Cad Drawings\CAD-04\BECKER-PLAN15.dwg, 1/12/2005 10:17:23 AM, HP Deskjet 1220C Printer
5/16/11

Case Study 7

Hampton Inn, 2020 Schafer St. 1/3/20 - 1-13-2020

Hampton Inn, 2020 Schafer St. 1-13-2020: Session 1

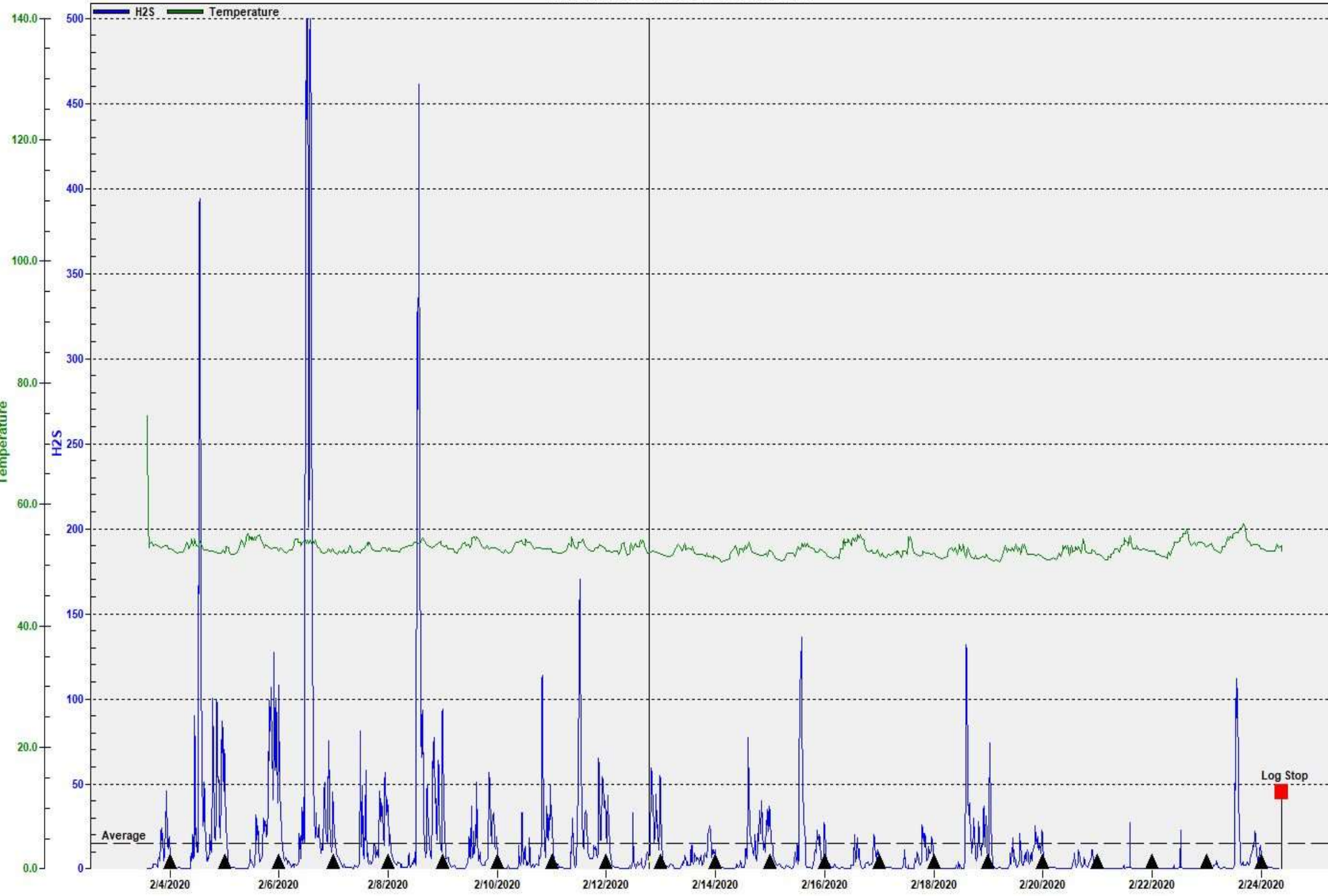


Period Displayed: 1/3/2020 - 1/13/2020 (Oda File: Hampton Inn, 2020 Schafer St. 1-13-2020.oda -- Serial Number: Odalog Type L2-RTx 02709684 Instrument Range 0-0PPM)

Average 6 | Month Transition | Min 0 | Max 239 | (Use Screen Data Only)

Hampton Inn, 2020 Schafer St, 2/2/20 - 2/24/2020

Hampton Inn, 2020 Schafer St. 2-24-2020: Session 1

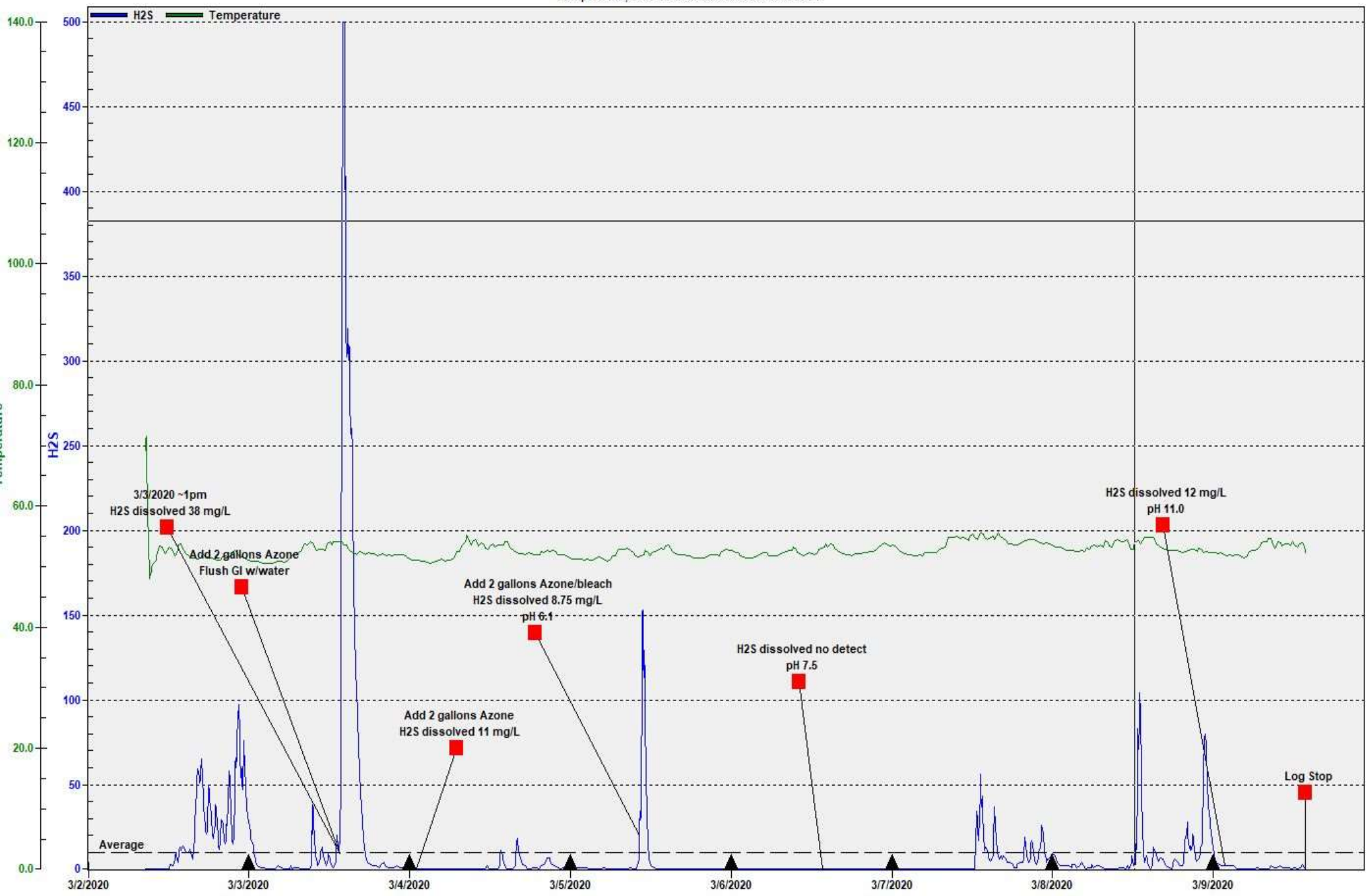


Period Displayed: 2/2/2020 - 2/25/2020 (Oda File: Hampton Inn, 2020 Schafer St. 2-24-2020.oda -- Serial Number: Odalog Type L2-RTx 02709684 Instrument Range 0-0PPM)

Average 15 | Month Transition Min 0 Max 542 (Use Screen Data Only)

Hampton Inn, 2020 Schafer St. 3/1/20 - 3/9/2020

Hampton Inn, 2020 Schafer St. 3-9-2020: Session 1



Period Displayed: 3/1/2020 - 3/9/2020 (Oda File: Hampton Inn, 2020 Schafer St. 3-9-2020.oda -- Serial Number: Odalog Type L2-RTx 06811214 Instrument Range 0-0PPM)

Average 10 | Month Transition Min 0 Max 560 (Use Screen Data Only)

Treatment Alternatives

- State the alternative treatment strategies
- Calculate the capital, chemical and operational costs
- List advantages & disadvantages of each option
- Get approval to pilot test
- Add cost to budget/financial plan

Recommendation

- Summarize the research results
- Recommend the strategies
- Identify action items
- After implementation provide follow-up verification of actual conditions

Summary

- Wastewater odor complaints are most often associated with hydrogen sulfide gas
- H2S can be oxidized or precipitated with chemicals
- Vapor phase odors can be treated with biological and/or chemical treatment methods
- Method selection should depend upon the concentration, efficiency, air flow and cost

Summary

- Treat each location to remove odors as unique
- Jar test to help identify which chemicals work for the local wastewater and conditions before pilot testing
- Pilot test some of the potential options
- Test the water and air for hydrogen sulfide before and during treatment, conditions change during the year, expect to make adjustments.
- Never expect to eliminate all odors all of the time from any process

Questions?

Contact Information

Industrial Pretreatment Program Manager and Lab Manager

- Bill Gefroh, 701-355-1763

- On line at www.bismarcknd.gov, Public Works Industrial Pretreatment