Estimating and Controlling Hydrogen Sulfide in Municipal Interceptors from a High Strength, High Temperature Industrial Wastewater

Presenters

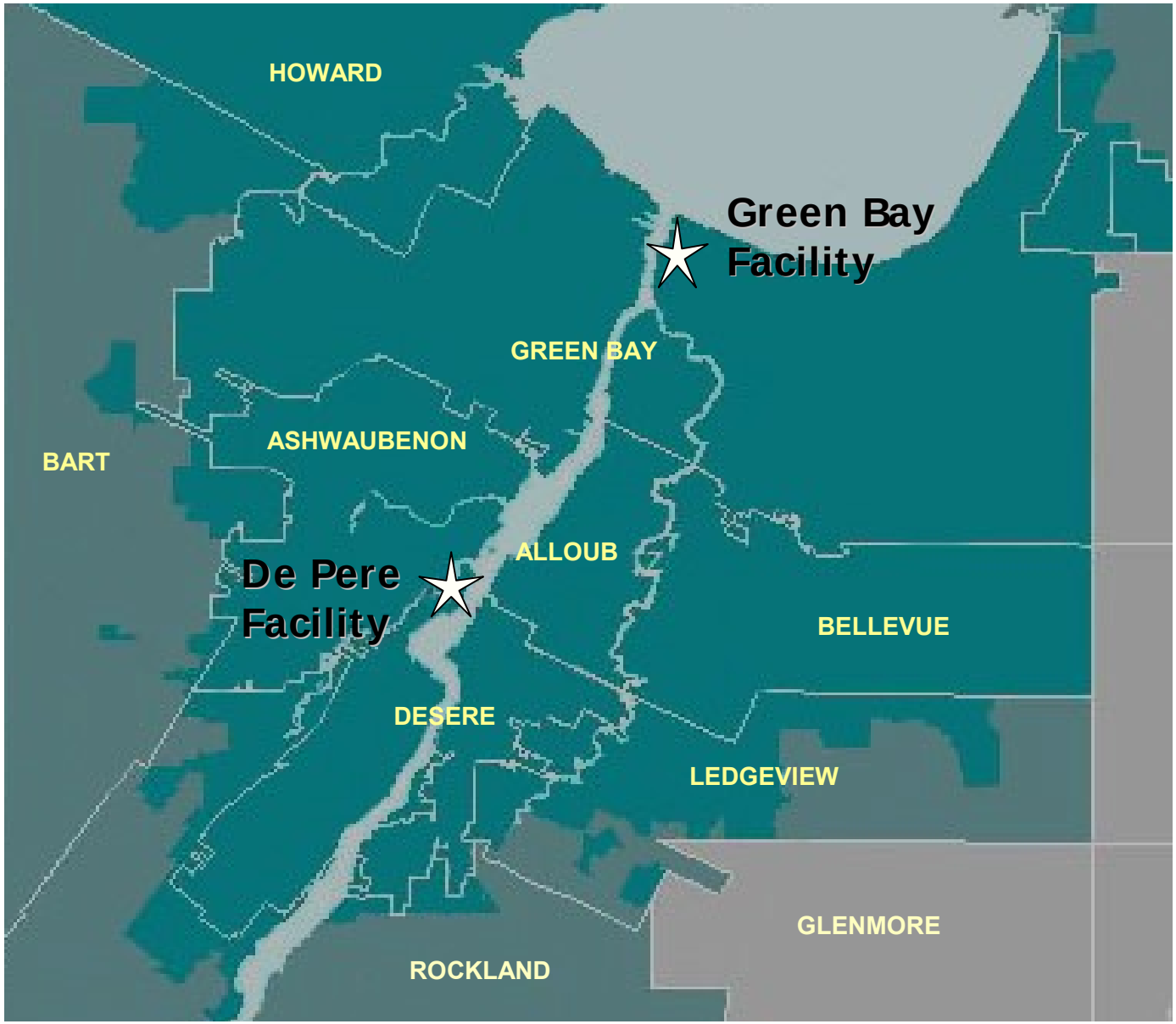
Bill Oldenburg – GBMSD

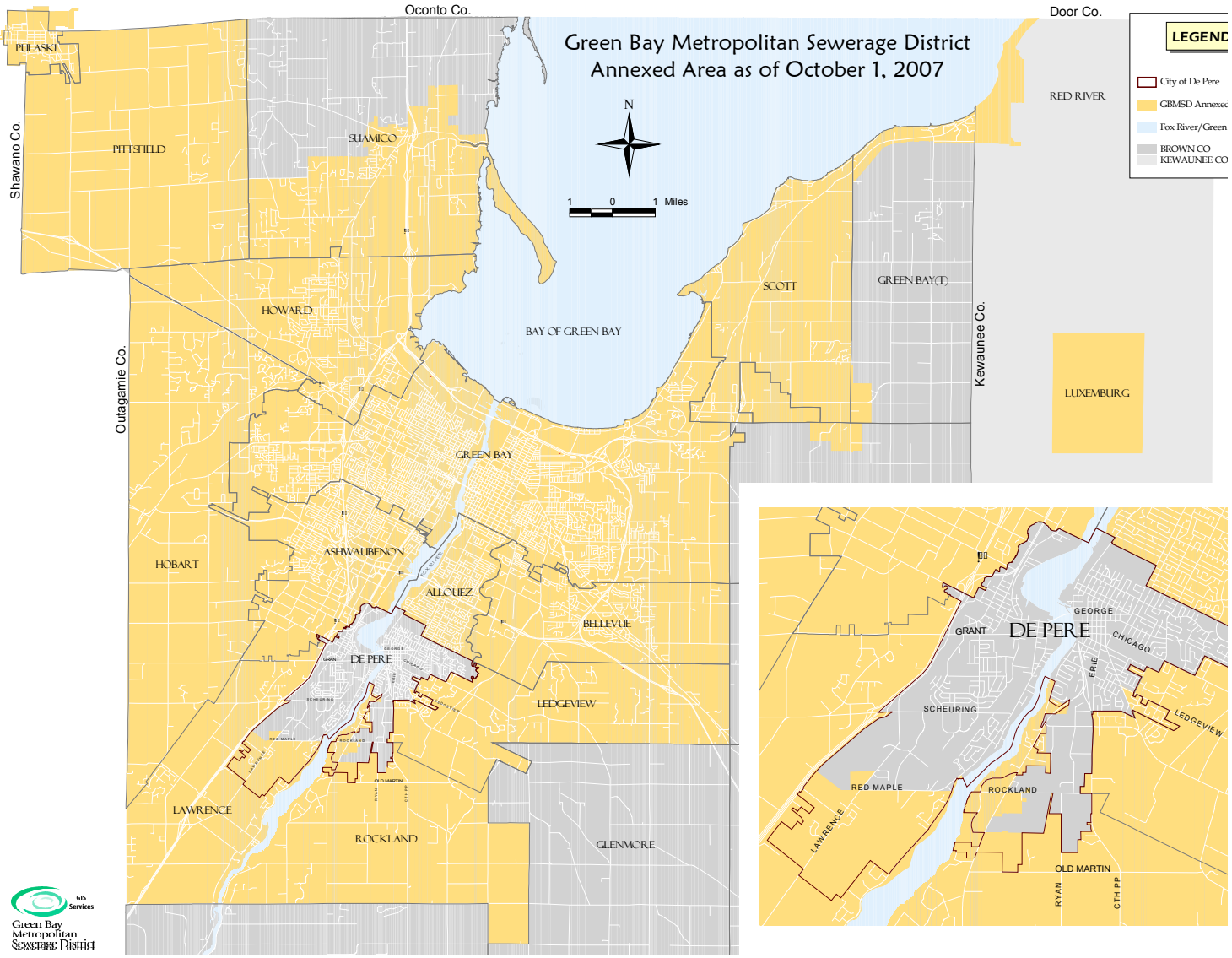
John Siczka – CH2M HILL

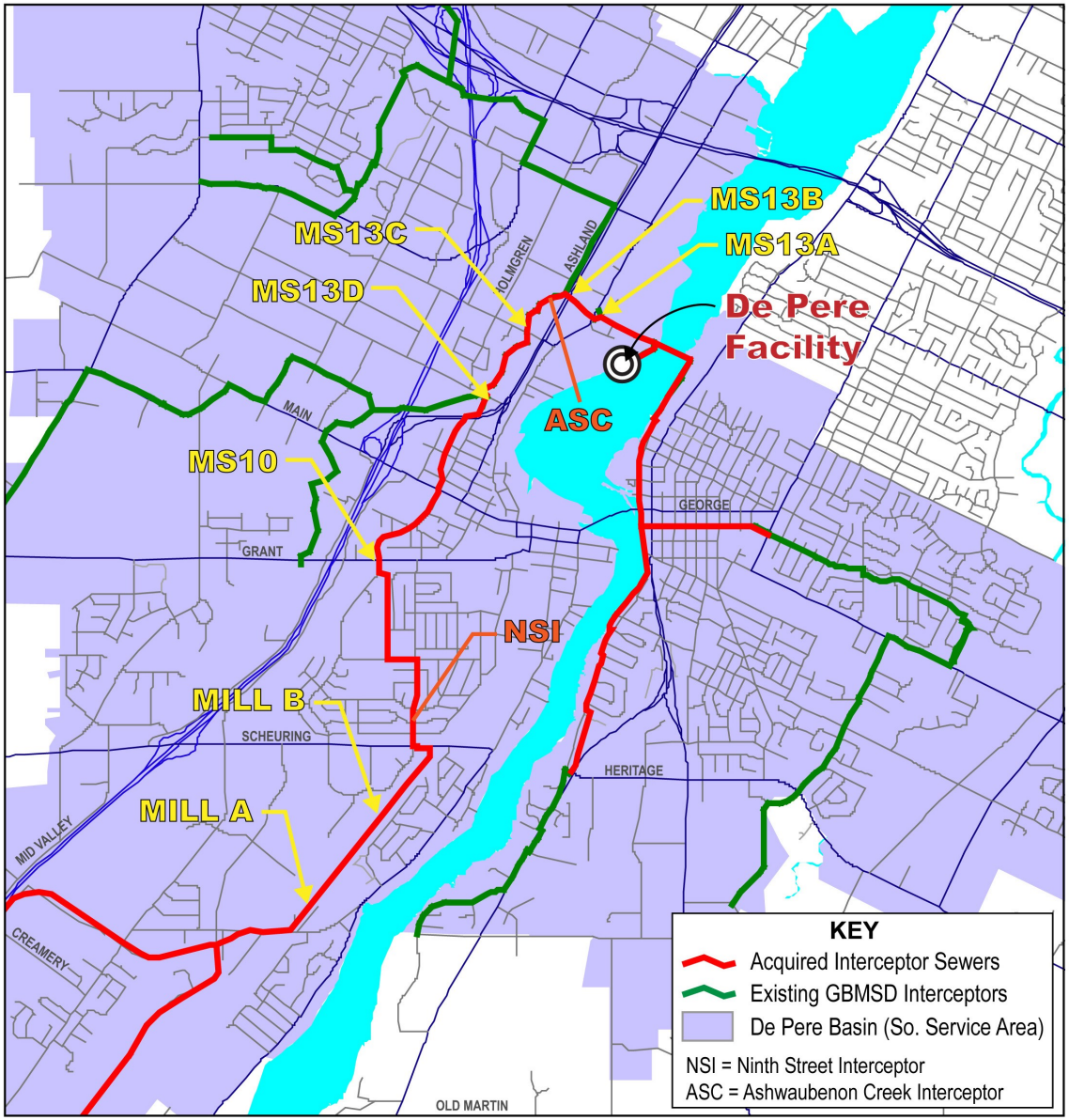
Agenda

- Background — Bill Oldenburg
- 2009 Sulfide Study — John Siczka
  - *Sulfide Generation*
  - *Modeling*
  - *Interim H_2S Limits*
  - *Interim Chemical Treatment*
  - *Permanent Solution*

- Two treatment facilities: Green Bay & De Pere
- GB Facility: 26 mgd (22.5 municipal + 4.5 mill)
- De Pere Facility: 8.4 mgd
- Annexed area = 277 square miles
- Service area = 131 square miles
- Gravity sewers: 77.2 miles
- Force mains: 24.6 miles
- 12 lift stations / 1 pumping station
- 17 municipal and one contract service customer


HOWARD
Green Bay Facility
GREEN BAY
ASHWAUBENON
BART
ALLOUB
De Pere Facility
BELLEVUE
DESERE
LEDGEVIEW
GLENMORE
ROCKLAND


Green Bay Metropolitan Sewerage District
Annexed Area as of October 1, 2007
Oconto Co.
Door Co.
Shawano Co.
Outagamie Co.
Kewaunee Co.
PULASKI
PITTSFIELD
SUAMICO
HOWARD
BAY OF GREEN BAY
RED RIVER
SCOTT
GREEN BAY(T)
LUXEMBURG
GREEN BAY
HOBART
ASHWAUBENON
ALLOUEZ
BELLEVUE
DE PERE
LEDGEVIEW
LAWRENCE
ROCKLAND
GLENMORE
N
1 0 1 Miles
LEGEND
City of De Pere
GBMSD Annexed
Fox River/Green
BROWN CO
KEWAUNEE CO
GEORGE
GRANT
CHICAGO
ERIE
SCHEURING
RED MAPLE
OLD MARTIN
RYAN
CTH PP
GIS Services
Green Bay Metropolitan Sewerage District


MS13C
MS13D
MS13B
MS13A
De Pere
Facility
ASC
MS10
NSI
MILL B
MILL A
JOLIMGREN
ASHLAND
MAIN
GRANT
GEORGE
SCHEURING
HERITAGE
MID VALLEY
CREAMERY
OLD MARTIN
KEY
Acquired Interceptor Sewers
Existing GBMSD Interceptors
De Pere Basin (So. Service Area)
NSI = Ninth Street Interceptor
ASC = Ashwaubenon Creek Interceptor

Prior to 1/1/2008

- Sewer Service Areas
- Four historical H_2S studies
- Connected interceptors with separate ownership
- Two separate sewer use ordinances
- Request for annexation and acquisition
- Due diligence work
- Ninth Street Interceptor /Ashwaubenon Creek Interceptor (NSI/ASC)

Impacts of Hydrogen Sulfide Release

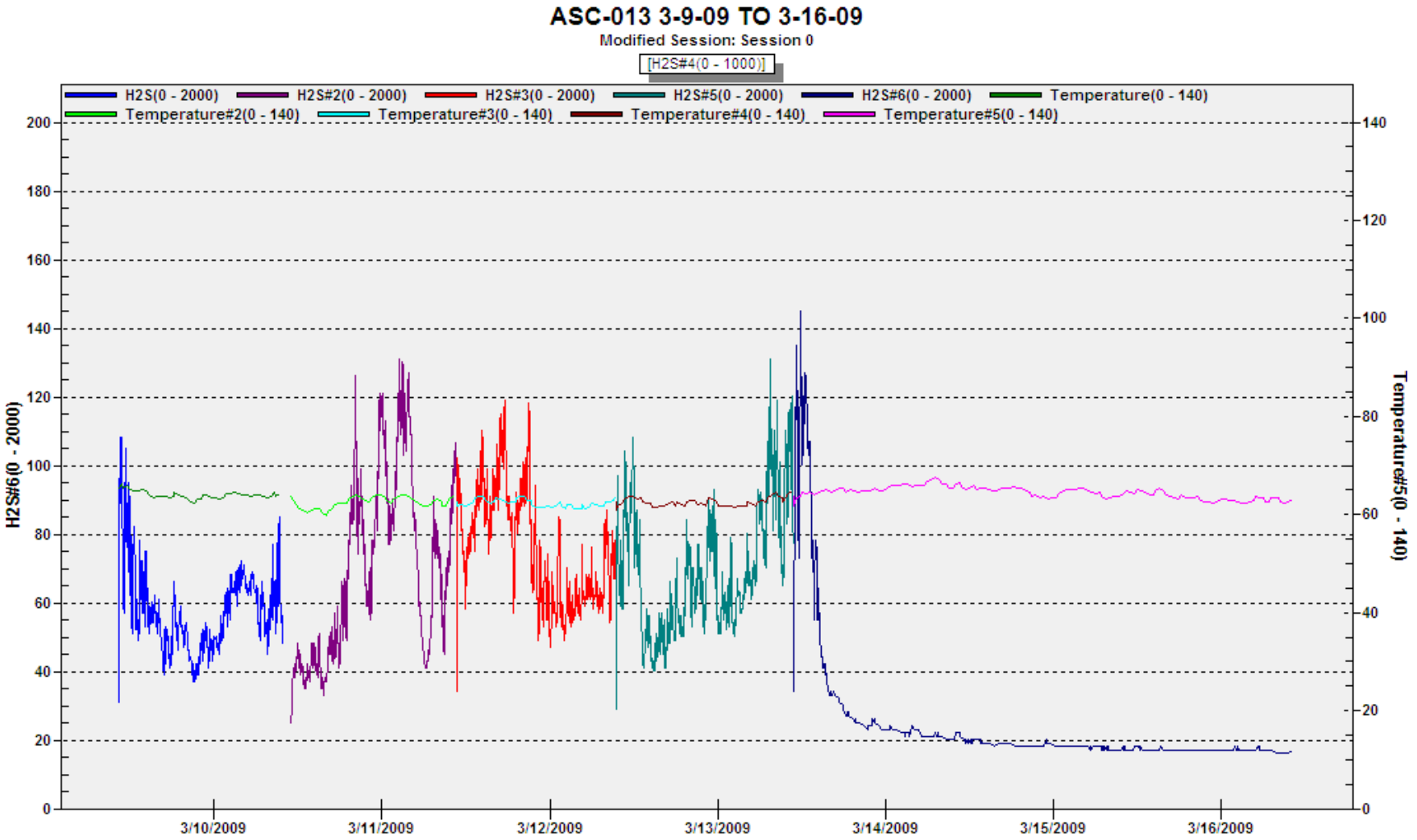
- Corrosion of sewers and treatment plant facilities
- Health and safety
  - *Workers*
  - *Public – migration through dry traps, etc.*
- Nuisance odors
  - *Collection system*
  - *Wastewater treatment plants*

Mill Wastewater Characteristics Discharging to NSI/ASC

Mill	Average Flow (gpd)	Average BOD (mg/L)	Average Temperature (°F)
Mill A	244,300	1,959	89.8
Mill B	767,000	2,259	104.4


OdaLog
H2S
ALOG 5
Green Bay
Metropolitan
ewerage District
2007/05/29

NSI/ASC – MH ASC-013: Vapor Phase H_2S



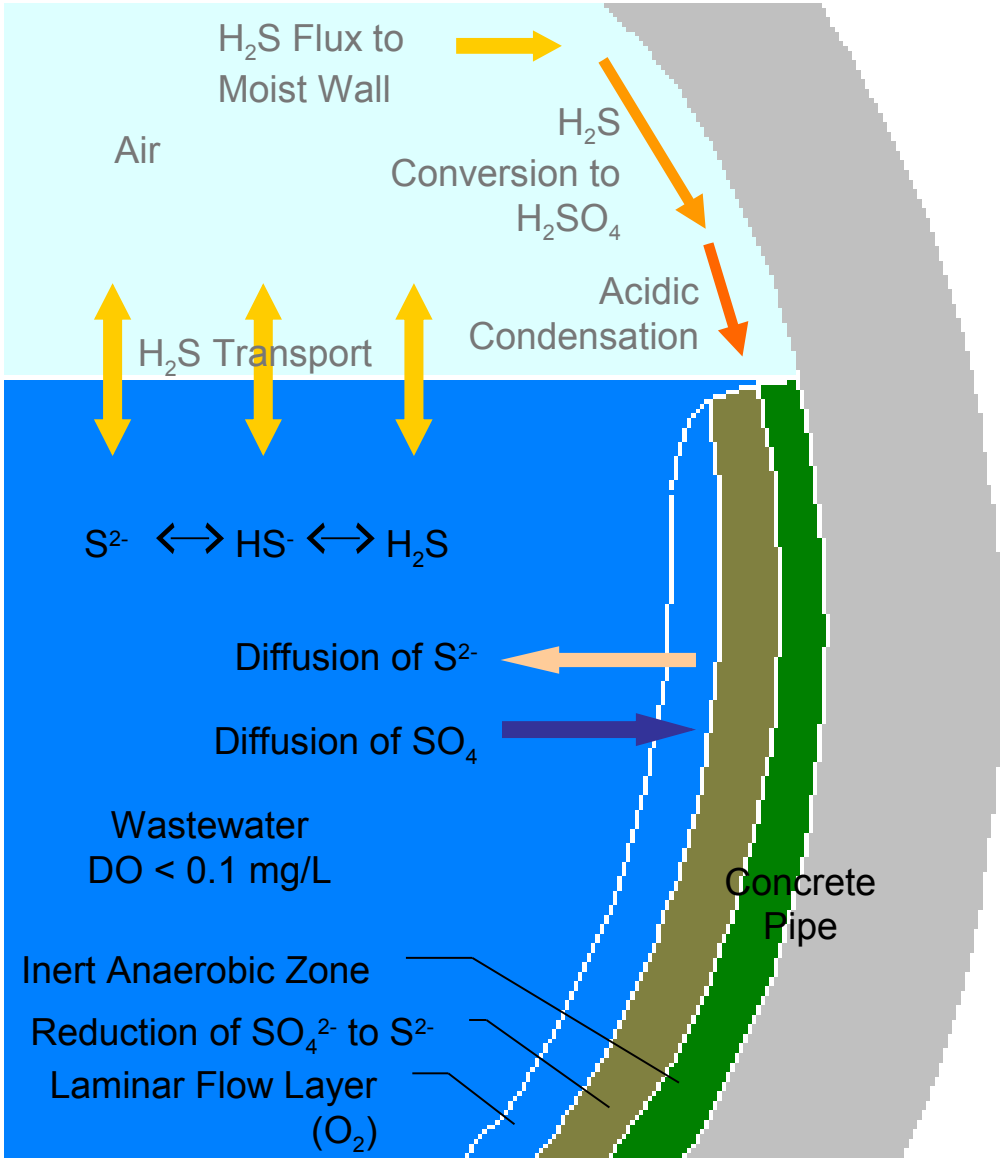

Reinforcement Visible Chem
+0311.6414


SRVC(Surface
Counter
From: 05
Remarks:

Generation of Sulfides

- Sulfate (SO_4^{2-}) + Anaerobic Bacteria → Sulfides
- Sources of sulfates
  - *Potable water*
  - *Ground water infiltration into sewers*
  - *Sulfates from industrial, commercial and domestic source*
- Sulfide generation almost always not limited by amount of sulfates in wastewater

Sulfide Generation in Sewer Pipes



Generation of Sulfides

- Sewer slime mechanisms
  - *Sulfates converted to sulfides in aerobic zone*
  - *Oxygen in aerobic zone oxidizes these sulfides*
  - *When oxygen insufficient (<0.1 – 1 mg/L), sulfides diffuse into wastewater*
  - *Several factors influence depth of aerobic zone and oxygen concentration*

Parameters that Effect Sulfide Generation

- Higher velocity = less sulfide generation
  - *Oxygen consuming solids don't settle*
  - *Slime layer/anaerobic zone is thinner*
  - *More oxygen transfer from wastewater to aerobic zone*
  - *More sewer slope = higher velocity*
  - *However, higher sewer slope increases turbulence and stripping of sulfides to sewer vapor headspace*

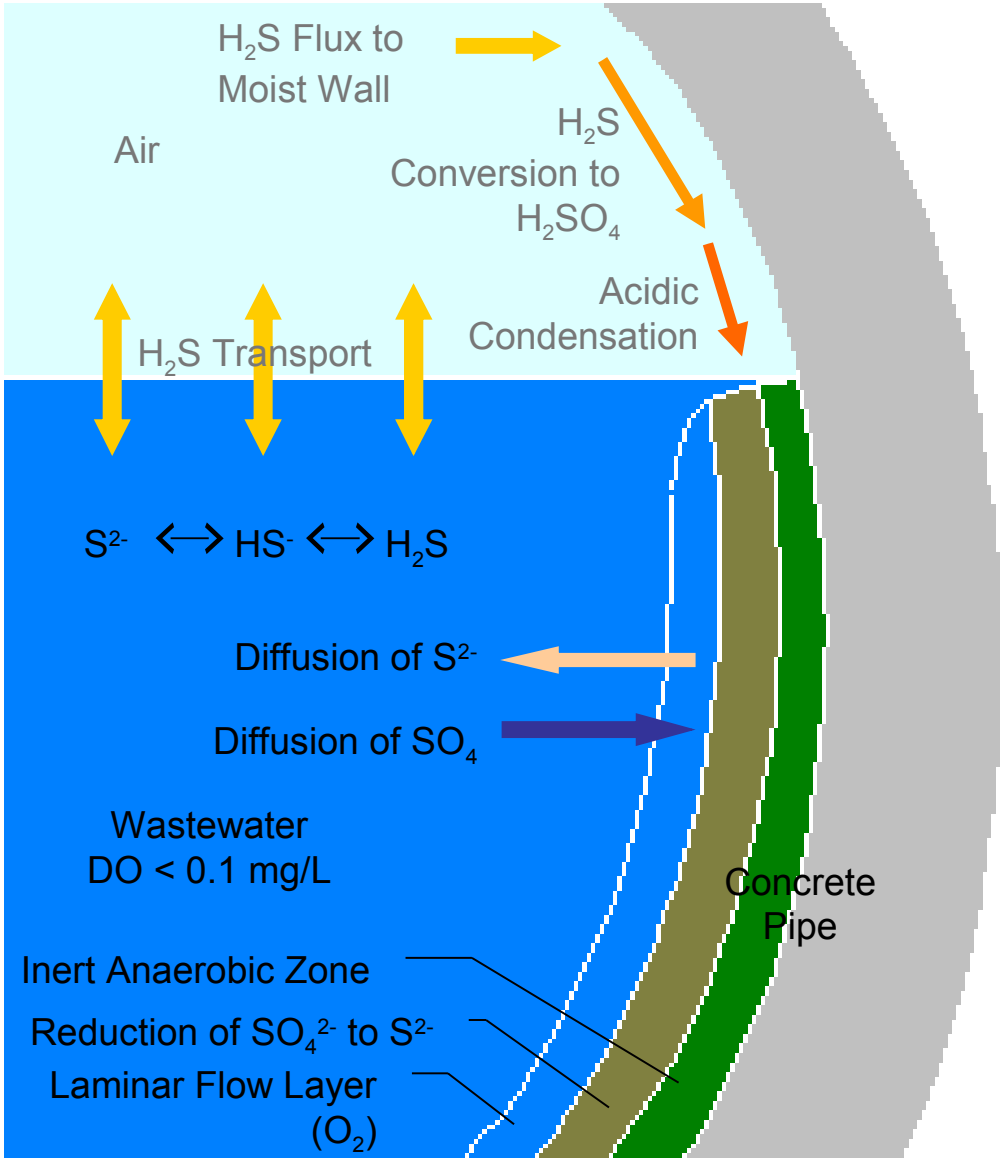
Parameters that Effect Sulfide Generation

- Higher BOD = more sulfide generation
  - *Higher oxygen demand, reduces wastewater dissolved oxygen and the ability of aerobic bacteria to oxidize sulfides produce in the anaerobic slime layer zone*
  - *More BOD provides more food for anaerobic bacteria*

Parameters that Effect Sulfide Generation

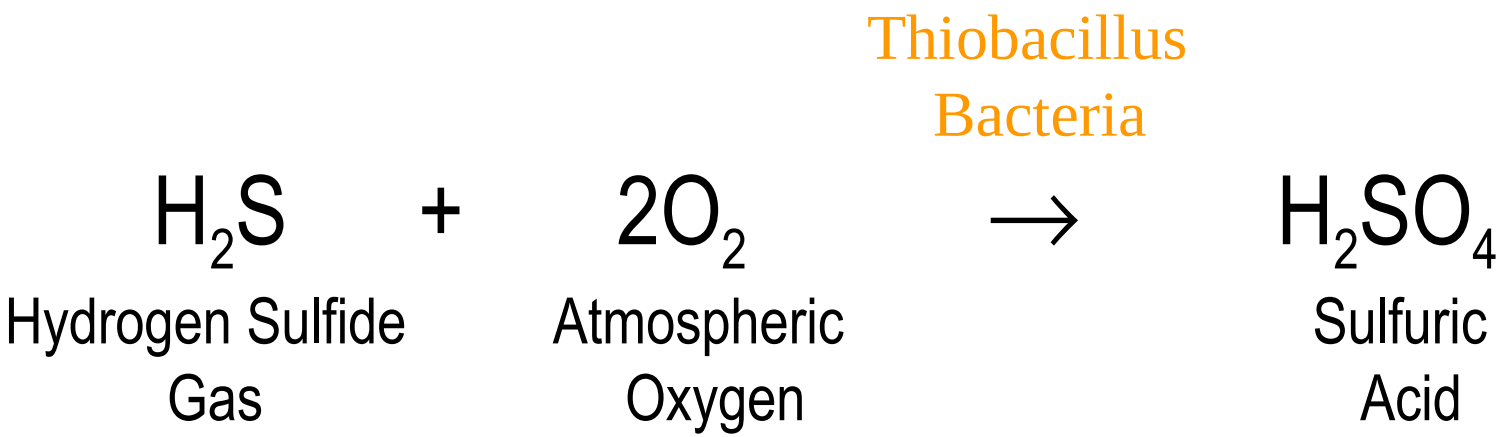
- Higher temperature = more sulfide generation
  - *Increases kinetics and speed of reactions*
- Higher detention time / low flows = more sulfide generation
  - *More time for reactions to occur (e.g. conversion of sulfates to sulfides)*

- Release of H_2S depends on:
  - *Turbulence – drops, high velocity, slope changes*
  - *Ventilation rate*
  - *pH – more H_2S present at lower pH*



Corrosion

- Corrosion rate dependent on:
  - *Alkalinity*
  - *Suface pH*
  - *Wall thickness*
  - *Concrete mix*

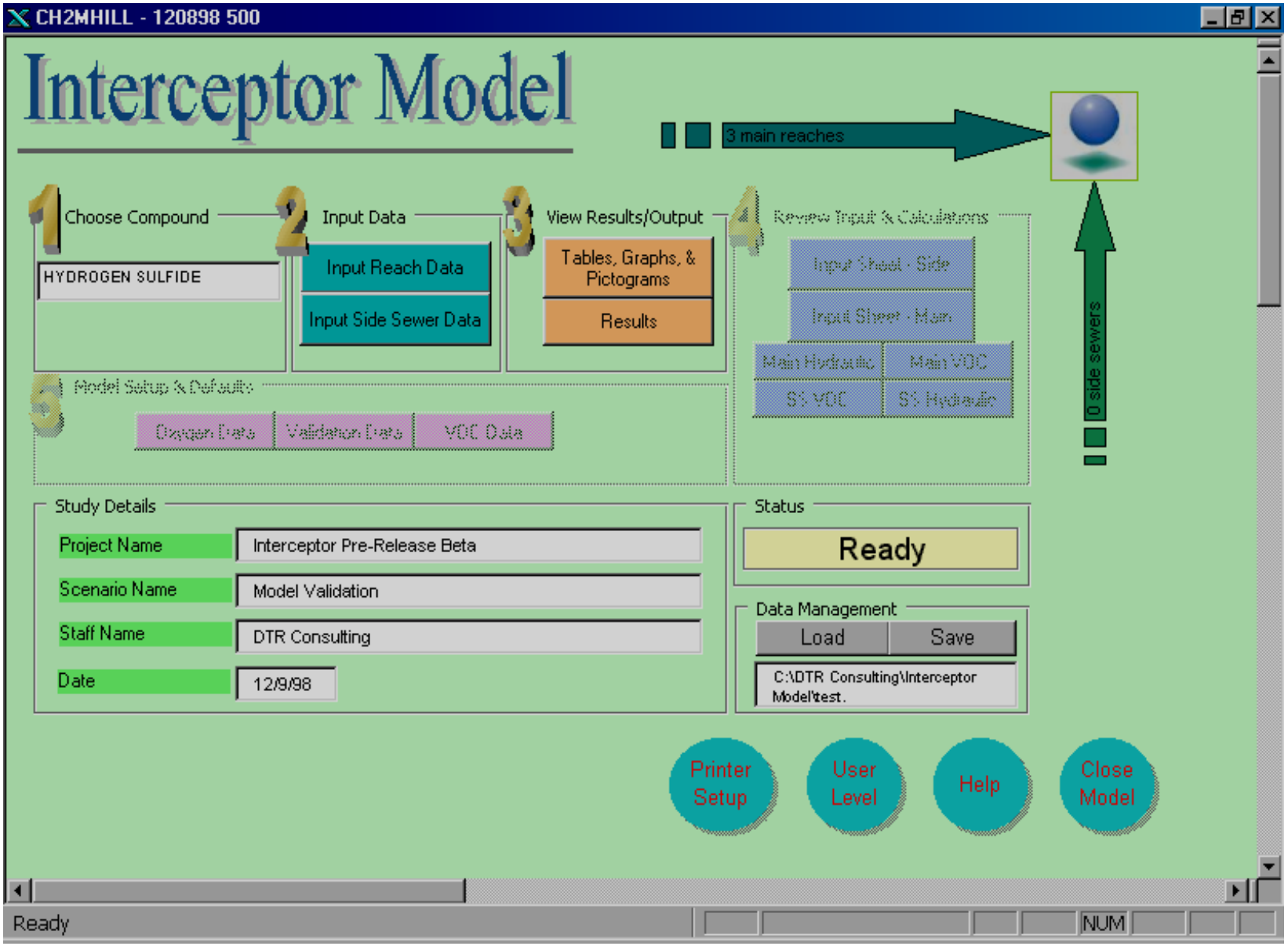


INTERCEPTOR Model

- Predicts both liquid and vapor phase hydrogen sulfide concentrations
- Previous models (Pomeroy and Parkhurst) only predicted liquid phase
- Vapor phase concentrations determine odor and corrosion impacts
- Applicable to both gravity lines and force mains

INTERCEPTOR Model – Used to Determine Methods for Reducing Odors

- Impacts on changes in wastewater BOD, flows, temperatures
- Determine chemical dosages and optimum addition points
- Use vapor phase concentrations and air flow rates to size vapor phase treatment (carbon, scrubbers, etc.)
- Determine which manholes may require sealing or other odor control

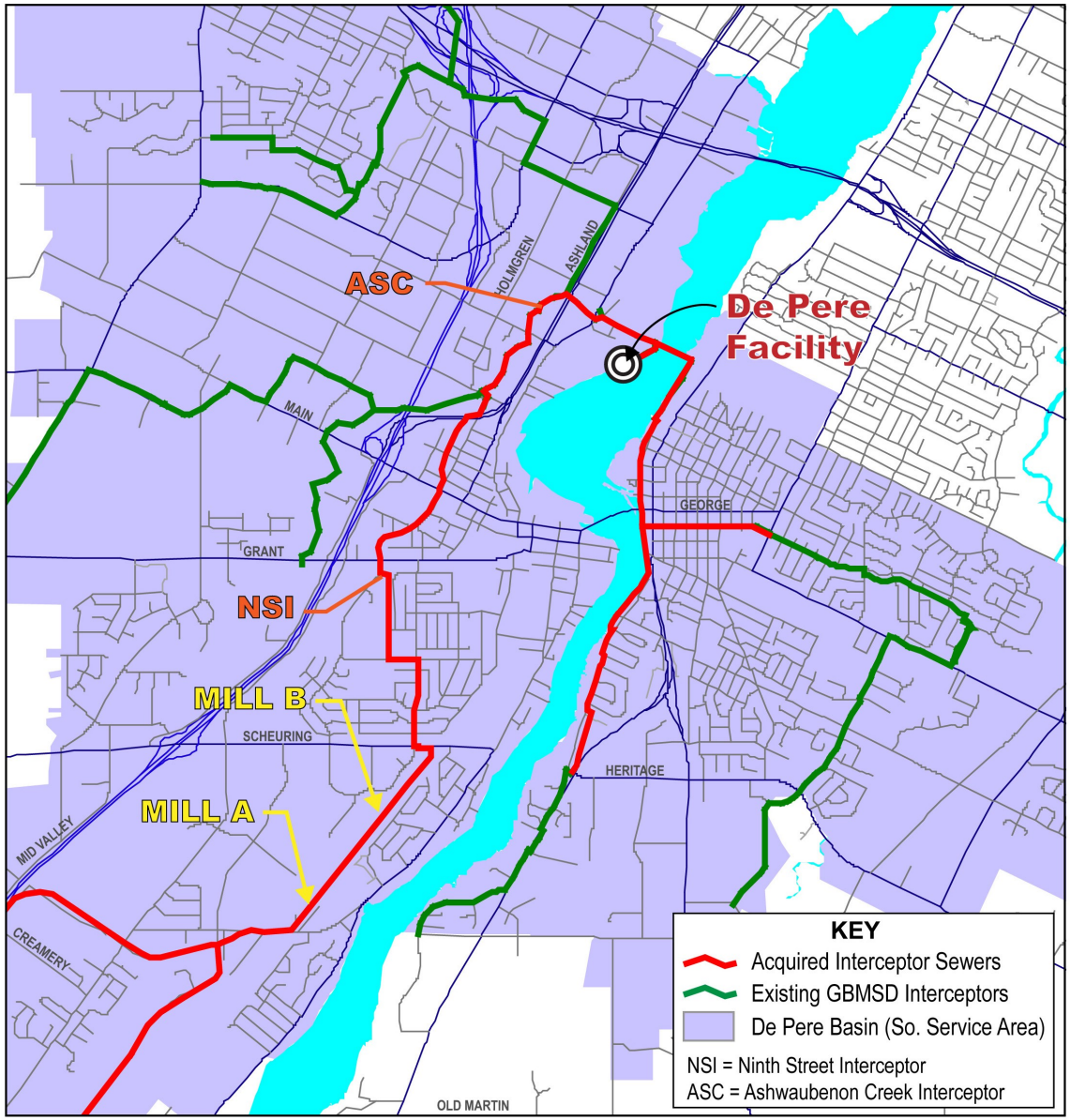

CH2MHILL - 120898 500
Interceptor Model
3 main reaches
0 side sewers
1 Choose Compound
HYDROGEN SULFIDE
2 Input Data
Input Reach Data
Input Side Sewer Data
3 View Results/Output
Tables, Graphs, & Pictograms
Results
4 Review Input & Calculations
Input Head - Side
Input Sheet - Main
Main Hydraulic
Main VOC
S1 VOC
S1 Hydraulic
5 Model Setup & Defaults
Oxygen Data
Validation Data
VOC Data
Study Details
Project Name
Interceptor Pre-Release Beta
Scenario Name
Model Validation
Staff Name
DTR Consulting
Date
12/9/98
Status
Ready
Data Management
Load
Save
C:\DTR Consulting\Interceptor Model\test.
Printer Setup
User Level
Help
Close Model
Ready
NUM

INTERCEPTOR Model Runs

- Calibrated with extensive vapor phase data
- Numerous scenarios run
  - *Different loading conditions*
  - *Different mill discharge temperatures*
  - *Only one mill operating*
  - *No mills operating*
- Models and data assisted in confirming mills were the source of high vapor phase H_2S

NSI/ASC INTERCEPTOR Model Selected Inputs

Location	Flow (gpd)	BOD (mg/L)	Temperature (°F)	Dissolved Oxygen (mg/L)	Dissolved Sulfide (mg/L)
Upstream of Mills	175,600	200	57	2	1.8
Mill A	244,300	1,959	96	0.5	1.8
Mill B	767,000	2,259	109	0.5	0.5
MS10	130,000	188	55	2	2
MS13D	70,000	1,364	60	0.5	3
MS13C	200,000	261	59	1	0
MS13B	2,450,000	211	57	1	0
MS13A	450,000	290	64	1	0


ASC
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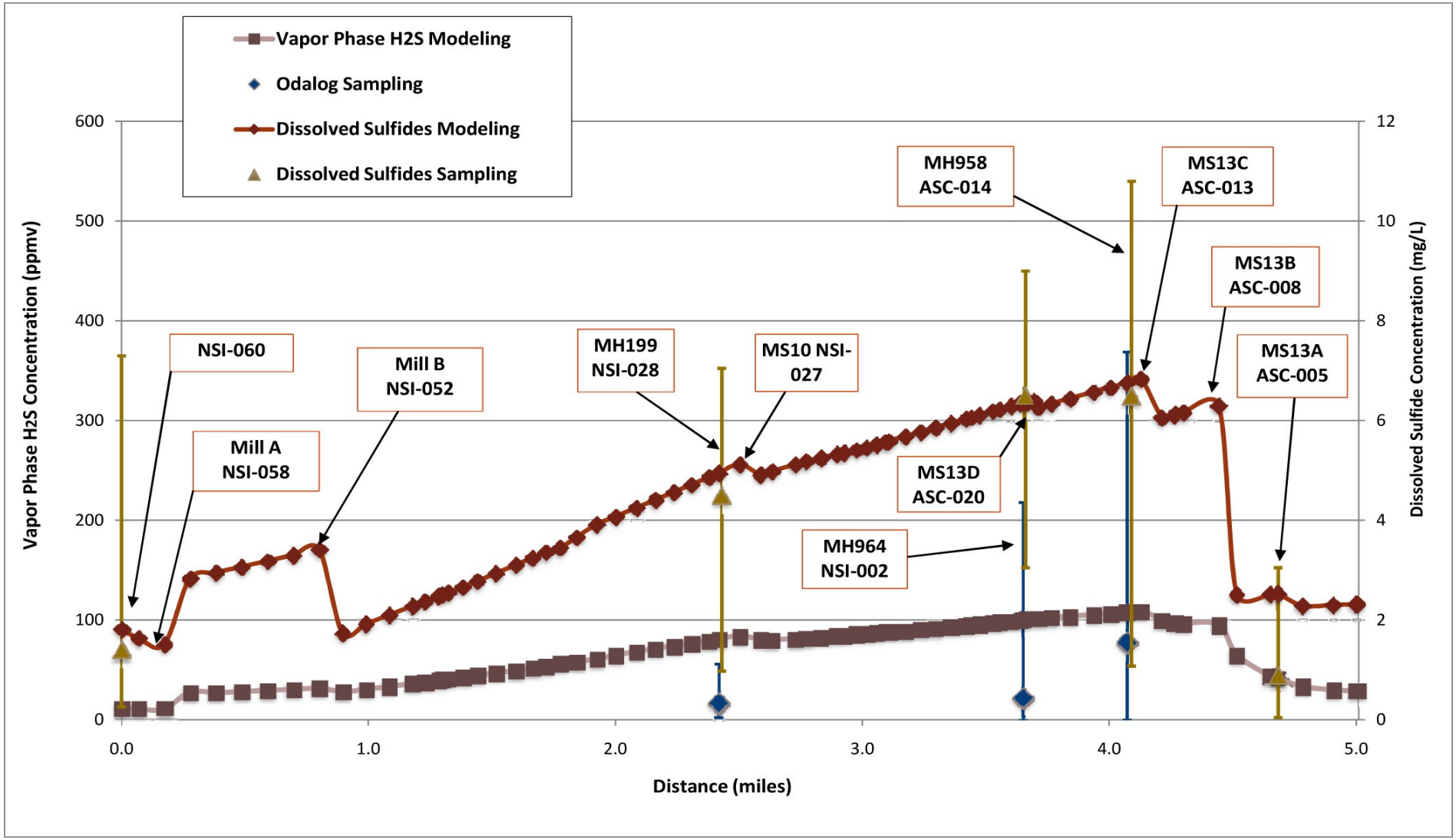
NSI/ASC Average Loading Condition: Modeling Predicted Sulfide Concentrations and Sampling Data



Interim Vapor Phase H_2S Limits

- Immediate addition of treatment chemicals
- GBMSD long term standards
  - *24 hour running average: 2 ppmv*
  - *Instantaneous Peak: 10 ppmv*
- Interim limits: protect public health and safety
  - *Dry traps*
  - *Worker safety*

Interim Vapor Phase H_2S Limits

- OSHA, ACGIH, and NIOSH limits consulted
- GBMSD interim standards
  - *24 hour running average: 20 ppmv*
  - *Instantaneous peak: 40 ppmv*
- Existing NIOSH standards and other proposed standards for worker exposure are lower
  - *Dilution by air prior to receptor*
  - *20 – 40 ppmv not usual (hazard to public)*
  - *40 ppmv below the IDLH concentration of 100 ppm and the OSHA 50 ppm short term PEL*

Interim Chemical Treatment

- Mills responsible for selecting and dosing chemicals with GBMSD and CH2M HILL guidance
- INTERCEPTOR model used to determine initial, conservative dosages
  - *Actual dosages slightly higher due to highly variable mill discharge*
- OdaLog© data reviewed on a weekly basis
  - *Assess effectiveness*
  - *Adjust chemical dosing*

Interim Chemical Treatment

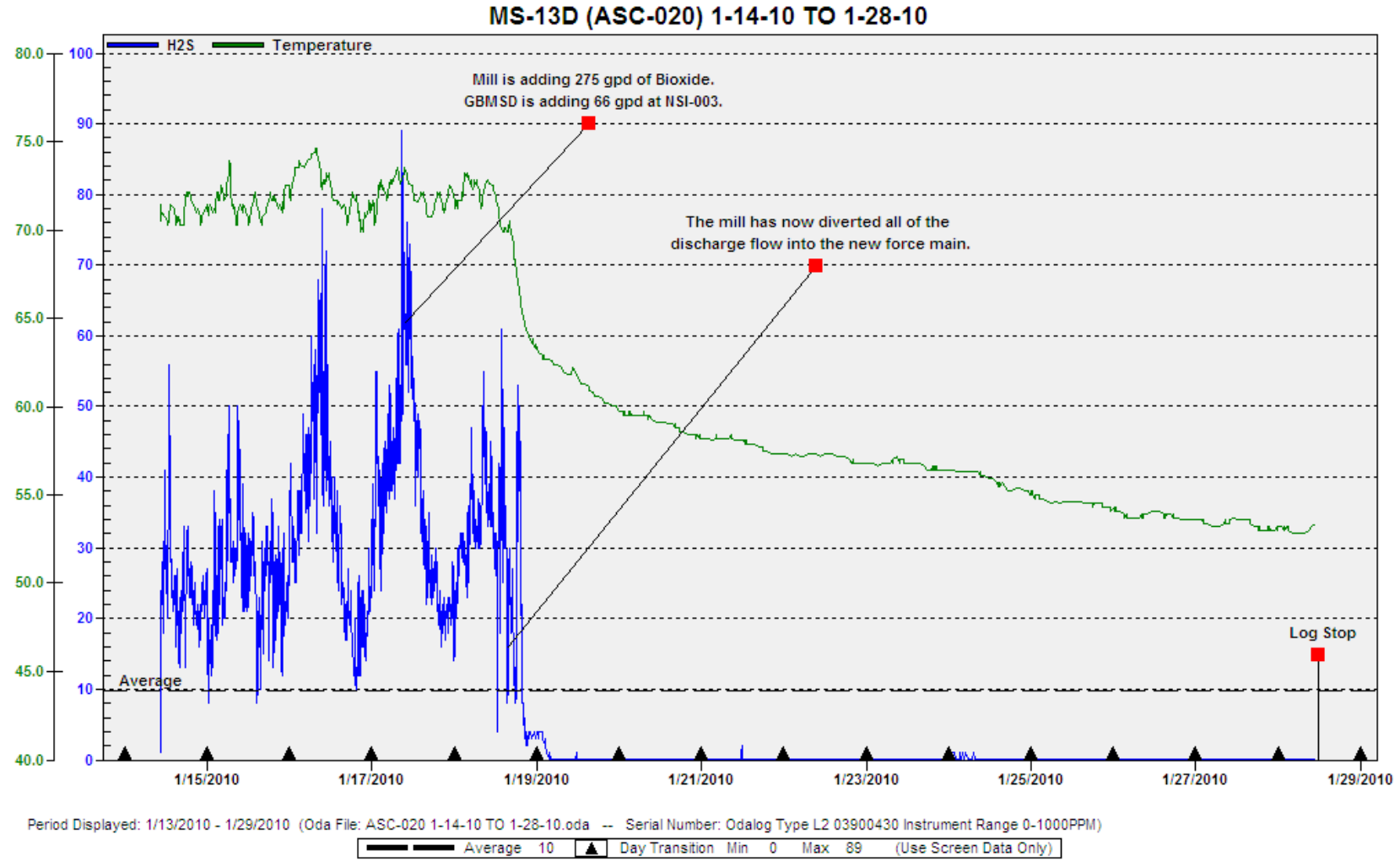
- Mill criteria: effective treatment at acceptable cost
- Mill A
  - *Not operating for an extended period of time*
  - *BIOXIDE® dosed when operating*
- Mill B
  - *Ferric chloride*
  - *Peroxide/calcium nitrate/catalyst blend*
  - *Ozone/oxygen*
  - *BIOXIDE®*

Permanent Solution

- Dedicated mill waste force mains
  - *Mill B to De Pere Facility (12” dia, 3.7 miles)*
  - *De Pere Facility to Green Bay Facility (10” dia, 6.9 miles)*
- Force main construction completed January, 2010
- Mill A
  - *Alter manufacturing process*
  - *Chemical dosing*


HOWARD
De Pere Facility-Green Bay Facility Mill Waste Force Main
Green Bay Facility
GREEN BAY
SHAWAUBENON
BART
De Pere Facility
ALLOUB
BELLEVUE
DESERE
Mill B
Mill B – De Pere Facility Mill Waste Force Main
LEDGEVIEW
GLENMORE
ROCKLAND

NSI/ASC – MH ASC-020: Vapor Phase H_2S Before and After Completion of Force Main



Force Main Sulfide Control – Toxicity

- INTERCEPTOR Model used
  - *Sulfide generation*
  - *Chemical dosing requirements (3 mg/L target)*
- Jar testing
  - *Chemical performance*
  - *Chemical dosing requirements*
- New chemical dosing stations
  - *De Pere Facility*
  - *Intermediate Chemical Feed Building*
  - *Ferric chloride or BIOXIDE®*

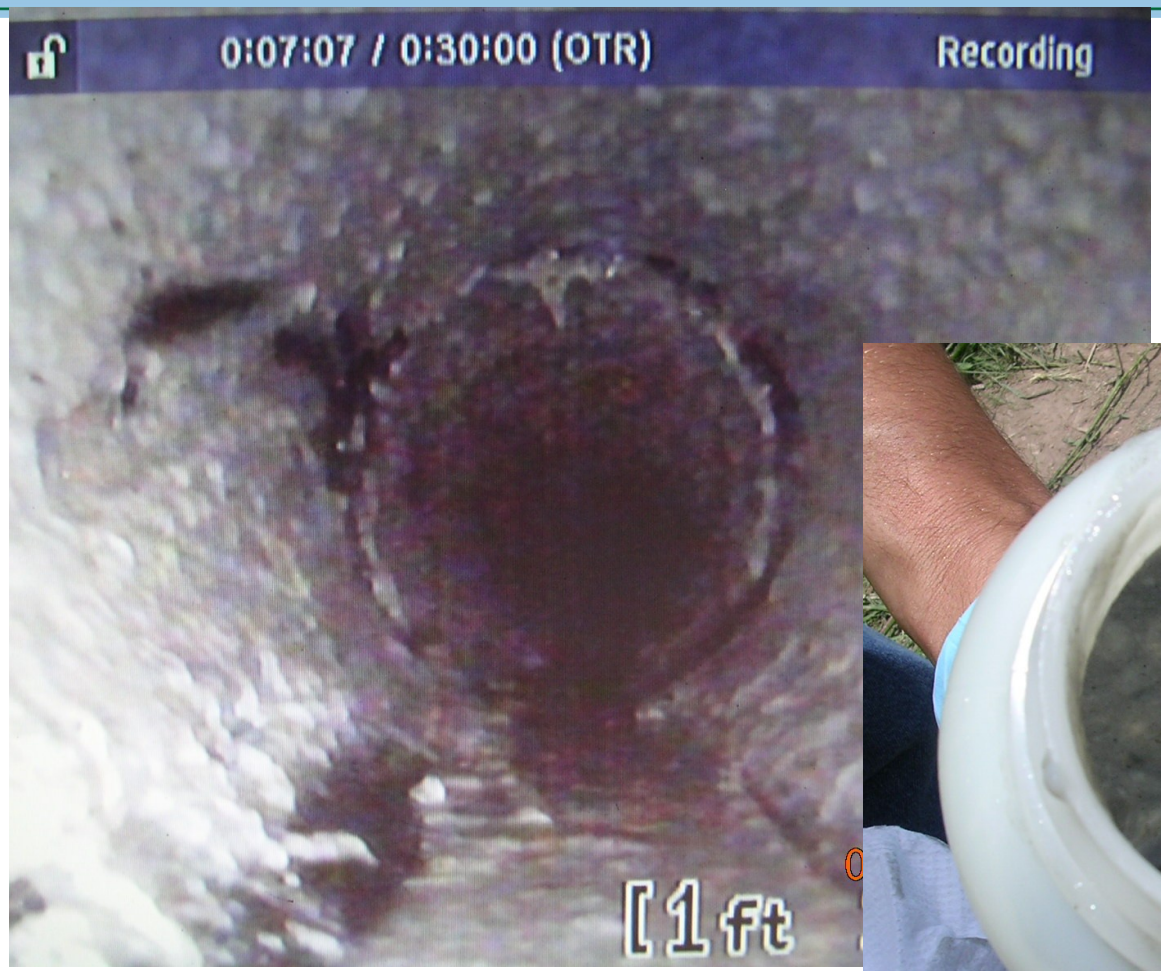
Mill Waste Force Main Operation

Mill Waste Force Main Location	INTERCEPTOR Predicted Dissolved Sulfides (mg/L)	Actual Dissolved Sulfides (mg/L)
De Pere Facility	110	1 - 2
Green Bay Facility	117	5 – 10

- Discharge pressures in De Pere - Green Bay force main much higher than design pressure

Mill Waste Force Main Operation

- Visual inspection of De Pere – Green Bay force main
  - *0.5 inch slime layer in force main*
  - *Proteinaceous slime unique to paper mill wastewater*
- Exists in both force mains but more prevalent in De Pere – Green Bay force main
  - *Appears to not be temperature related*
- Discharge pressures have stabilized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Recording
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07.01.2010

Mill Waste Force Main Operation

- Proteinaceous slime may reduce sulfide generation by:
  - *Inhibiting the activity of the sulfate reducing bacteria biofilm*
  - *Physically covering the biofilm*
  - *Retarding transfer of food to the bacteria*
  - *Retarding transfer of sulfide to the wastewater*
  - *Creating environment not conducive to sulfate reducing bacteria*
- Dosing ferric chloride at the Green Bay Facility

Estimating and Controlling Hydrogen Sulfide in Municipal Interceptors from a High Strength, High Temperature Industrial Wastewater

Questions?