

Acidic Mine Drainage in Sulfate-Reducing Bioreactors: Inside the SRB Cell.

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Geospatial Data Analysis

Acknowledgements

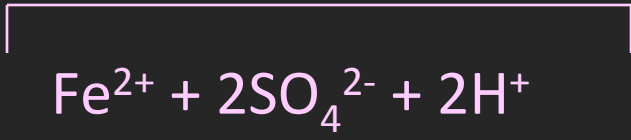
- Funding
 - U.S. Department of Interior Office of Surface Mining
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 - U.S. Forestry Service
- Partnership
 - Indiana Department of Natural Resources Division of Reclamation Restoration Section
- Participants
 - IGS Professional: Jack Haddan, Ron Smith, Margaret Ennis
 - **IU DOGS: Dr. Greg Olyphant**
 - IU Student Hourly: Sara Bergfeld, Jared Olyphant, Sashi Challa, Elizabeth Gawthrop, Janelle Steffen, Alex Gore, Elizabeth Bockstiegel, Scott Breeden

Remediation Strategies

prevention



treatment



precipitate
iron



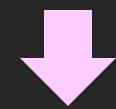
remove
sulfate



neutralize
acidity



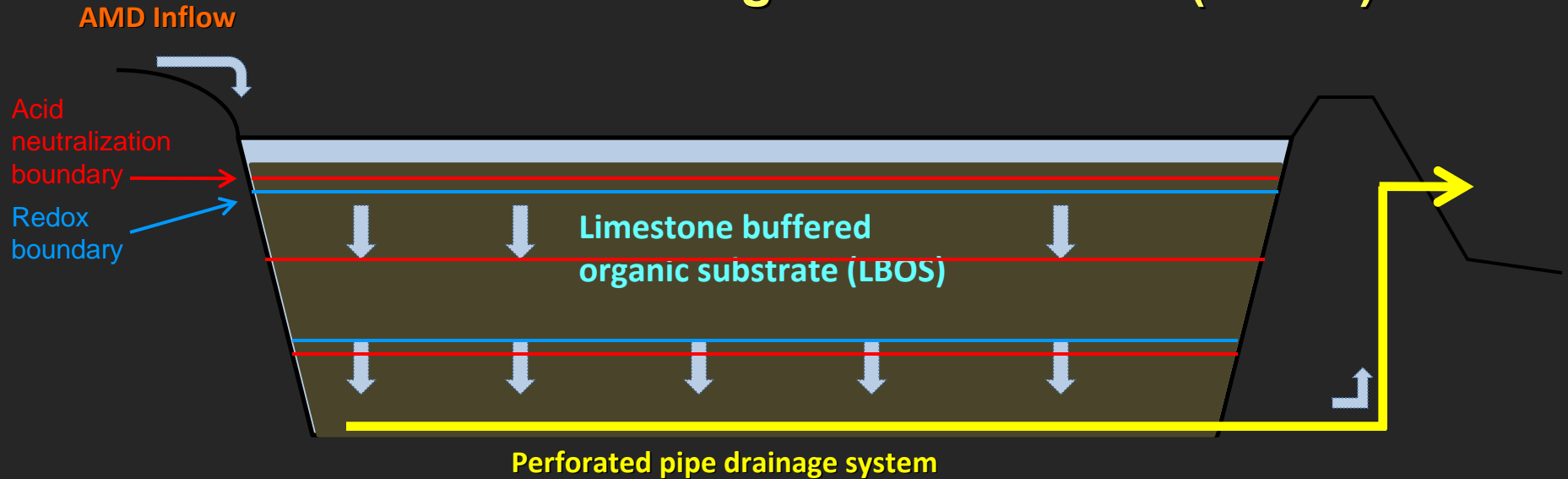
Utilize
bacteria



apply
alkalinity

Large Scale = Anaerobic Wetlands
Small Scale = Sulfate Reducing
Bioreactors

Sulfate-Reducing Bioreactor Cell (SRBC)



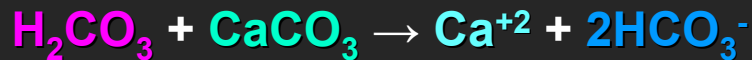
acid neutralization



aerobic bacteria removal of oxygen



anaerobic bacterial sulfate reduction



alkalinity generation



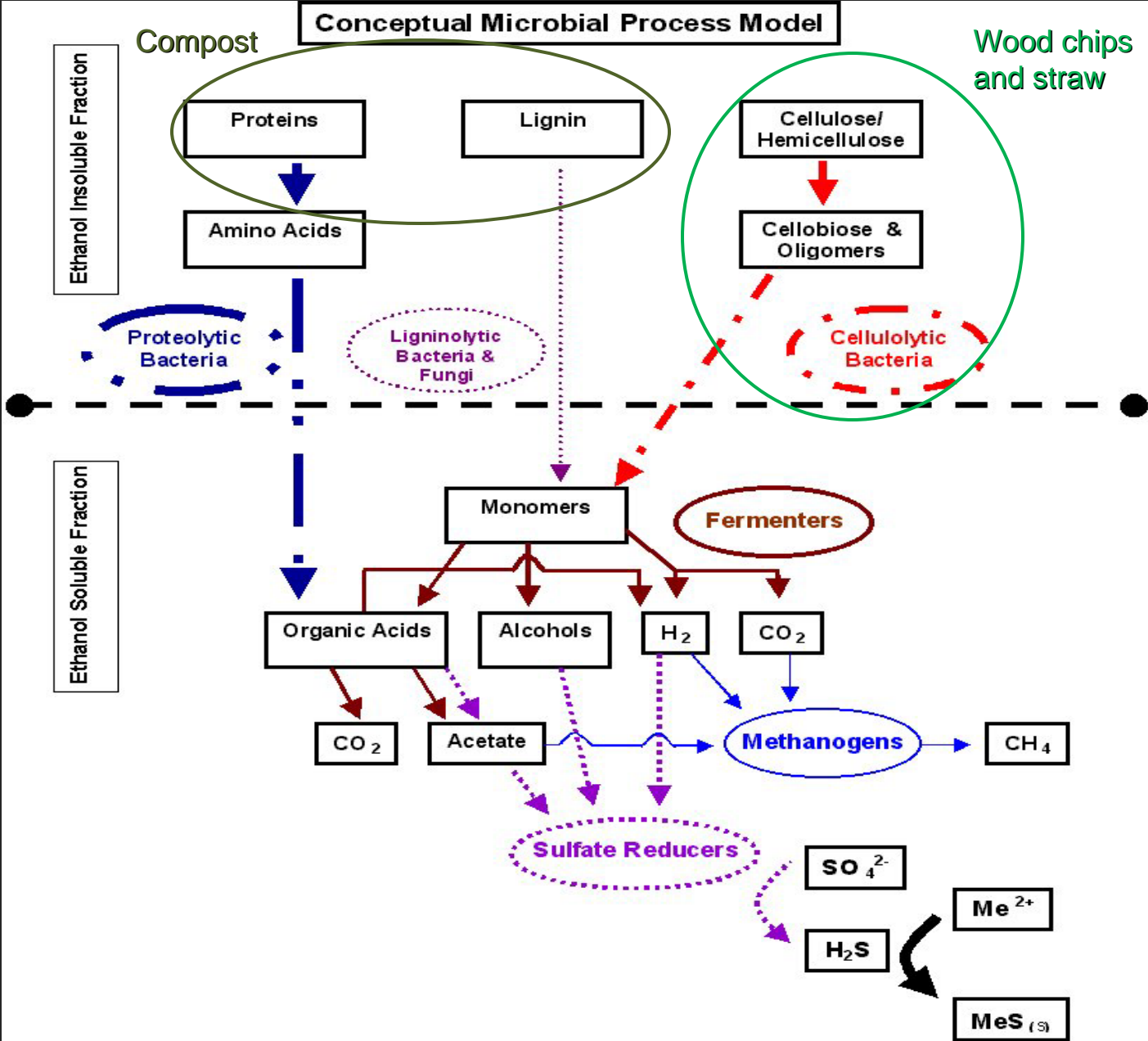
pH buffered hydrogen sulfide dissociation



ferrous iron sulfide precipitated

Fermenters, sulfate reducers and methanogens will starve and the bioreactor cease to function if the more complex organic molecules are not broken down to simpler molecules.

Rate of complex molecule decomposition is unknown but an important component for developing predictive model





Lacy Site, Martin County



Midwestern Site, Pike County

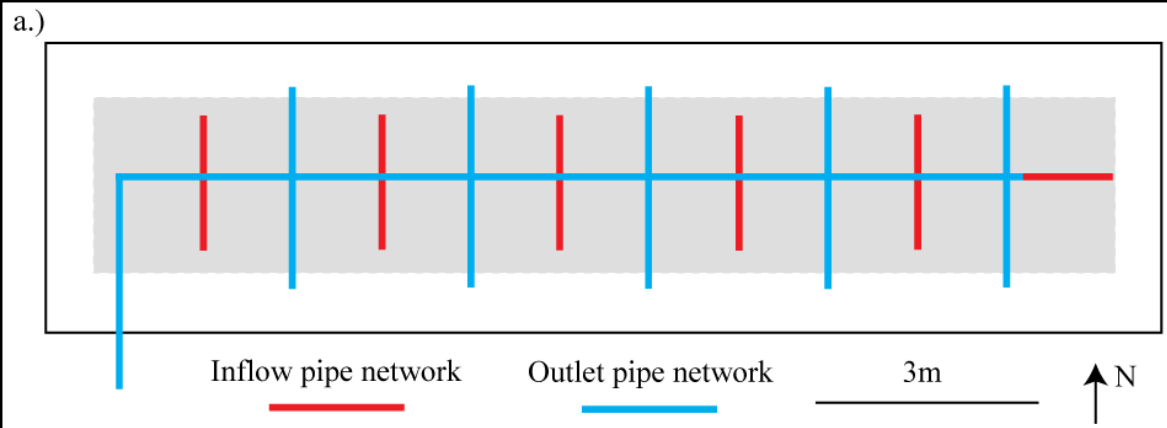


Average values obtained from 12+ months monitoring

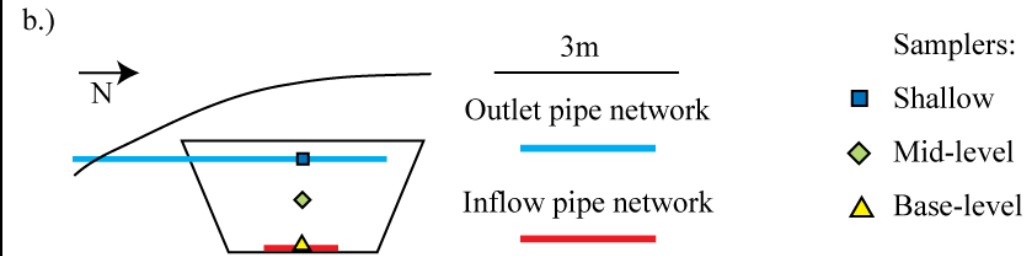
Sample ID	Temp	SpCond	pH	Eh	Acidity	Alkalinity	SO4	Fe(II)	Al	Mn
	C	uS/cm		mV	mg/L CaCO3	mg/L CaCO3	mg/L	mg/L	mg/L	mg/L
★ Lacy South seep	13.4	2883	2.5	612	1247	0	1547	259	64	3
Lacy South Outlet	15.7	2265	6.2	91	200	493	871	77	<0.05	11
Lacy N2 (North Seep)	18.2	3363	2.7	407	1499	7	2179	525	47	7
Lacy North Outlet	17.8	1829	6.3	168	162	285	591	86	<0.05	5
Midwestern Seep	17.0	3213	2.9	666	495	0	2386	54	10	12
Midwestern cell Outlet	13.8	1761	6.5	55	37	346	1098	13	<0.5	6

Lacy SRBC Design

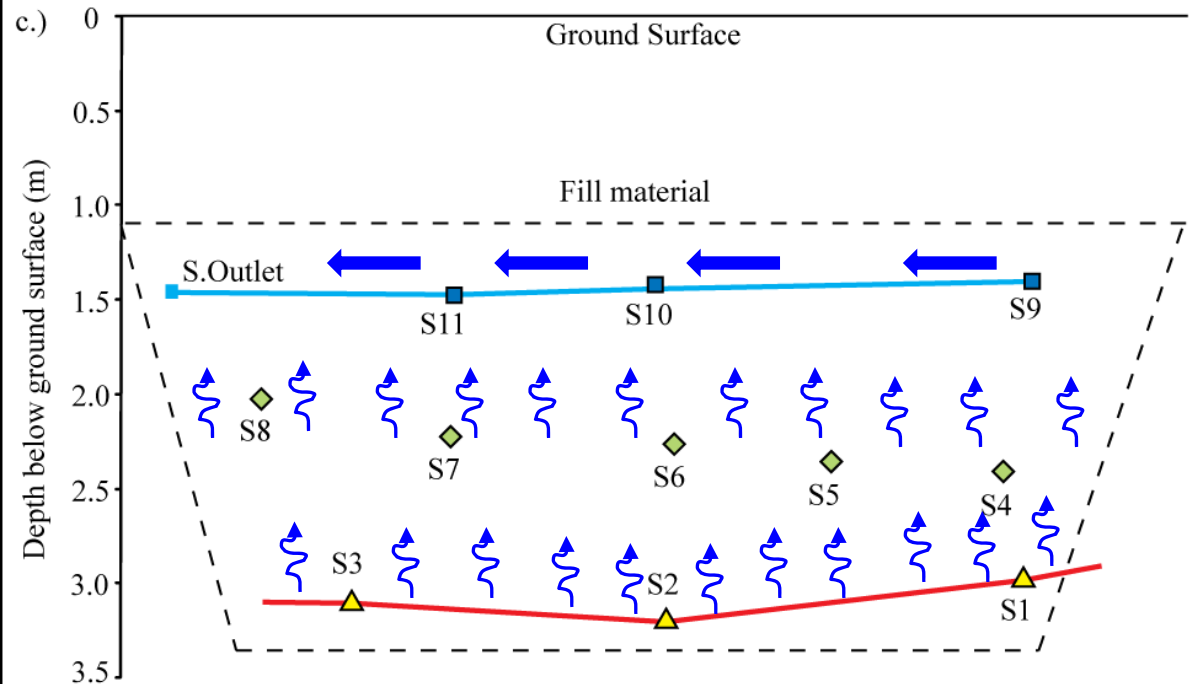
Plan View



Short dimension cross sectional view



Long dimension cross sectional view





Pipe level sampler



Floating sampler



**Pipe level sampler
in place**



Deploying floating samplers







Flow thru chamber
Multiparameter sonde

Peristaltic pump

Sampling ports

Filtration unit



S11 Rev
Wilcox

S. D. W
Wilcox

S11 Wilcox
Sulfate Nitrate
200 mg/L

S. D. W
Wilcox

S. D. W
Rev. P.
Wilcox

S11
P. P. P. P. P.
Wilcox

S. D. W
Wilcox

S. D. W
Wilcox

S. D. W
Wilcox

Red and white cooler

White plastic cup

Tools: knife, screwdriver, pliers

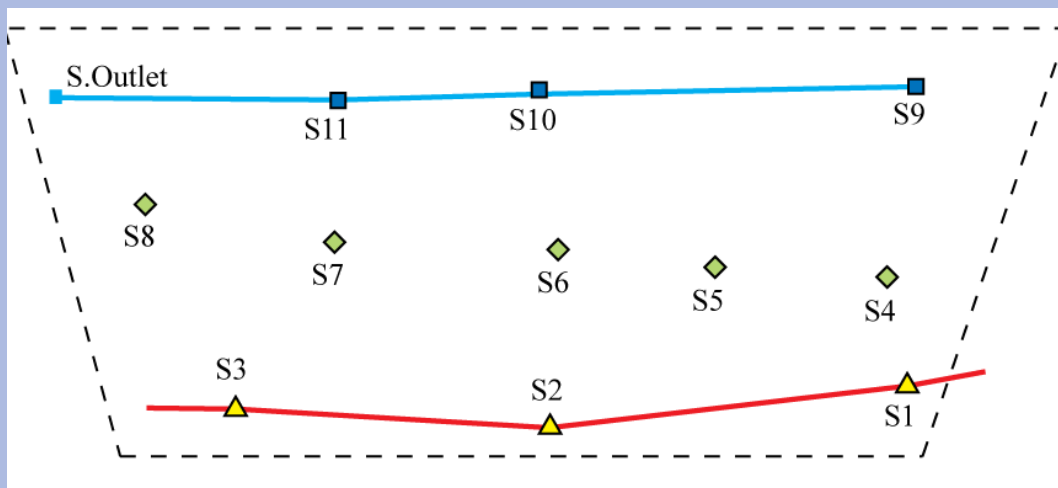
Digital scale with pink sticker '1'

S10 sulfate
Wilcox

S. D. W
Wilcox

S. D. W
Wilcox

Large white plastic jug

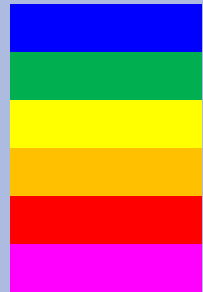


Ferrous Iron concentration range



Sulfate concentration range

**Sulfate
mg/L**



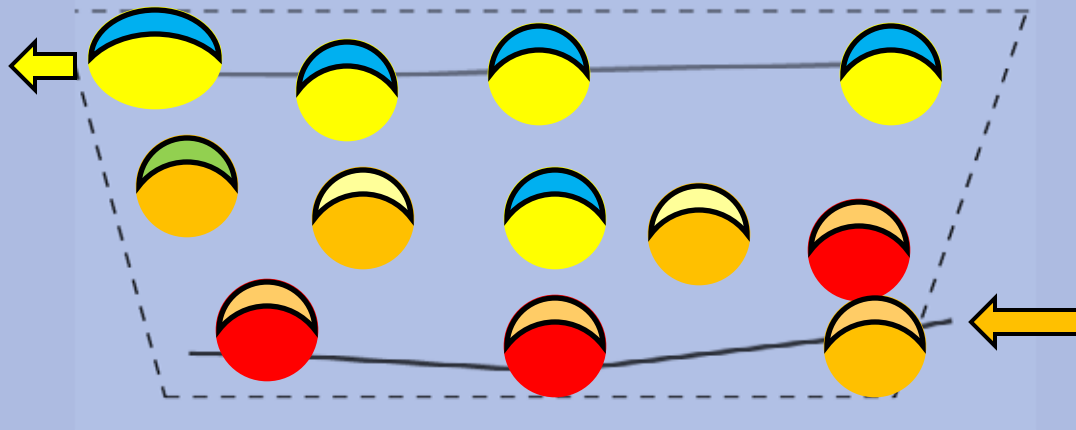
200
600
1000
1500
2000
3000

**Summer
2009**

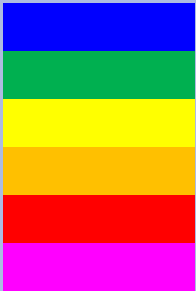
**Ferrous Iron
mg/L**



50
100
200
300
500
700



Sulfate
mg/L



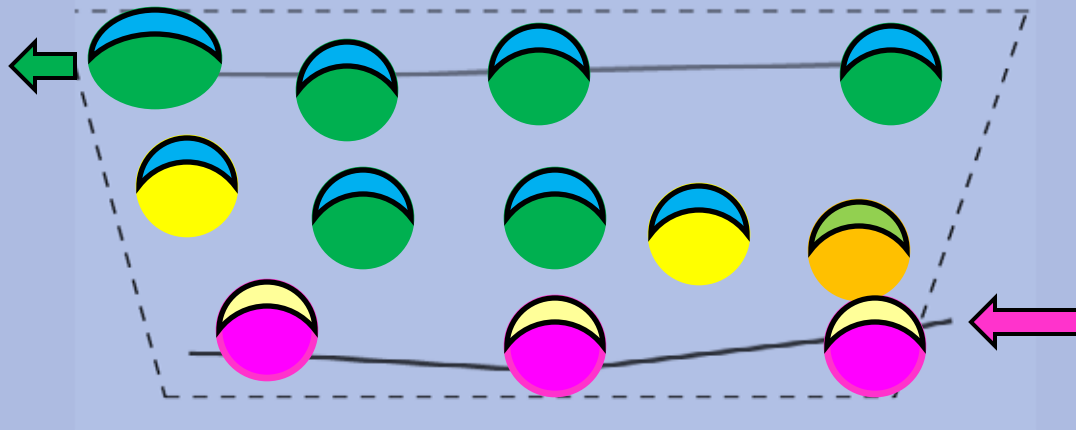
200
600
1000
1500
2000
3000

Fall
2009

Ferrous Iron
mg/L



50
100
200
300
500
700



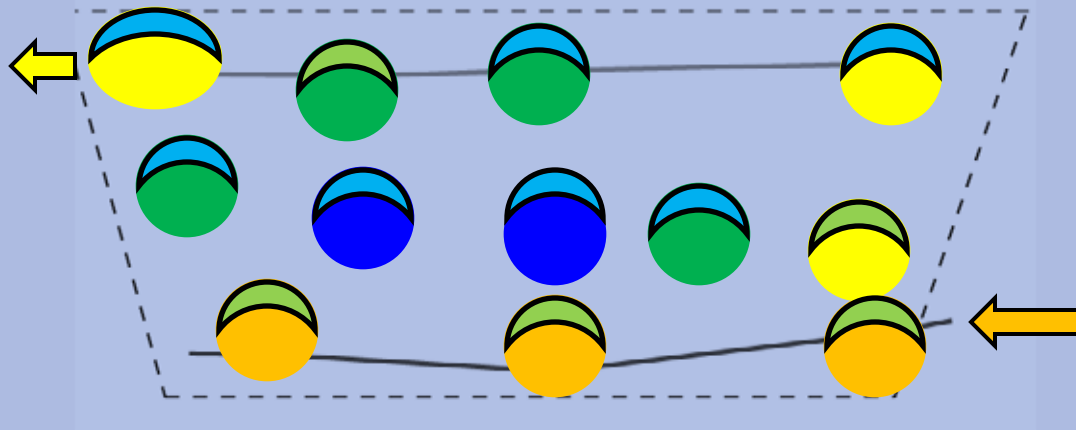
Sulfate
mg/L

200
600
1000
1500
2000
3000

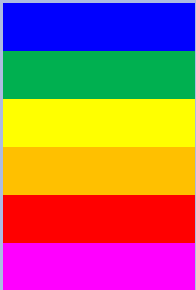
Ferrous Iron
mg/L

50
100
200
300
500
700

Winter
2010



Sulfate
mg/L



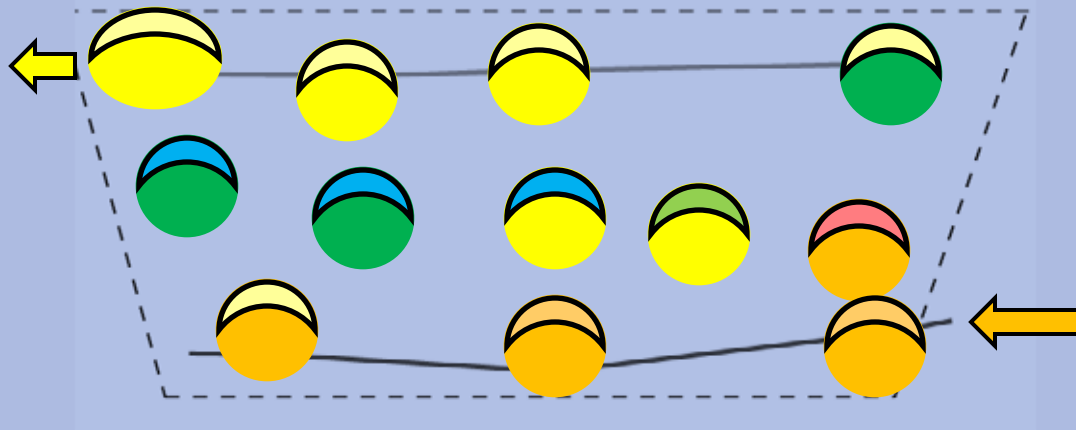
200
600
1000
1500
2000
3000

Spring
2010

Ferrous Iron
mg/L



50
100
200
300
500
700



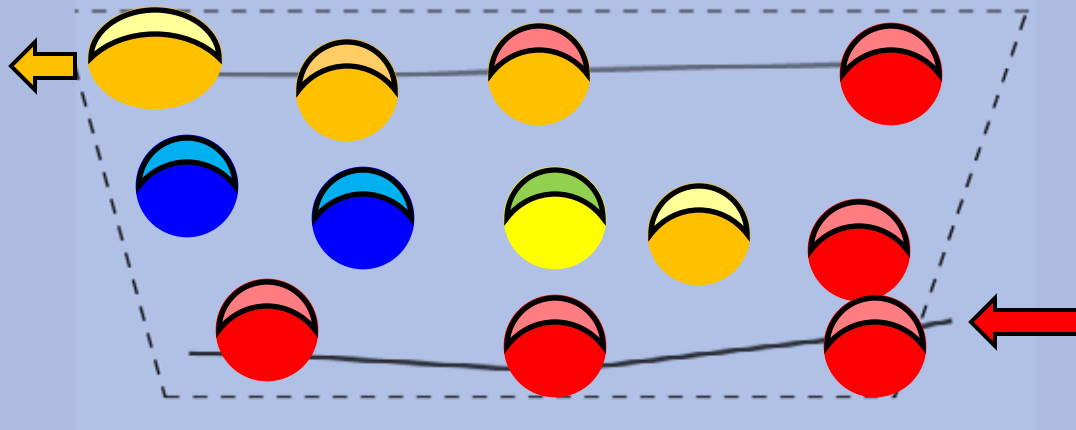
Sulfate
mg/L

200
600
1000
1500
2000
3000

Ferrous Iron
mg/L

50
100
200
300
500
700

Summer
2010



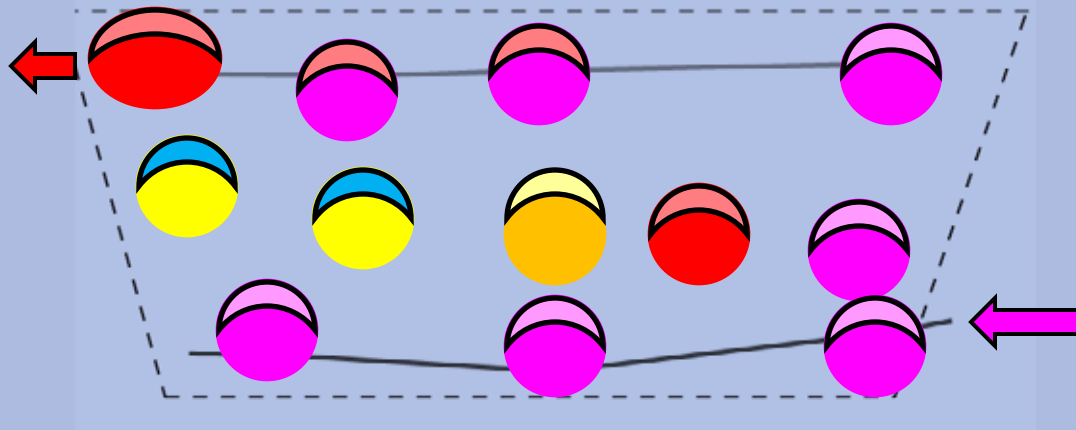
**Sulfate
mg/L**

200
600
1000
1500
2000
3000

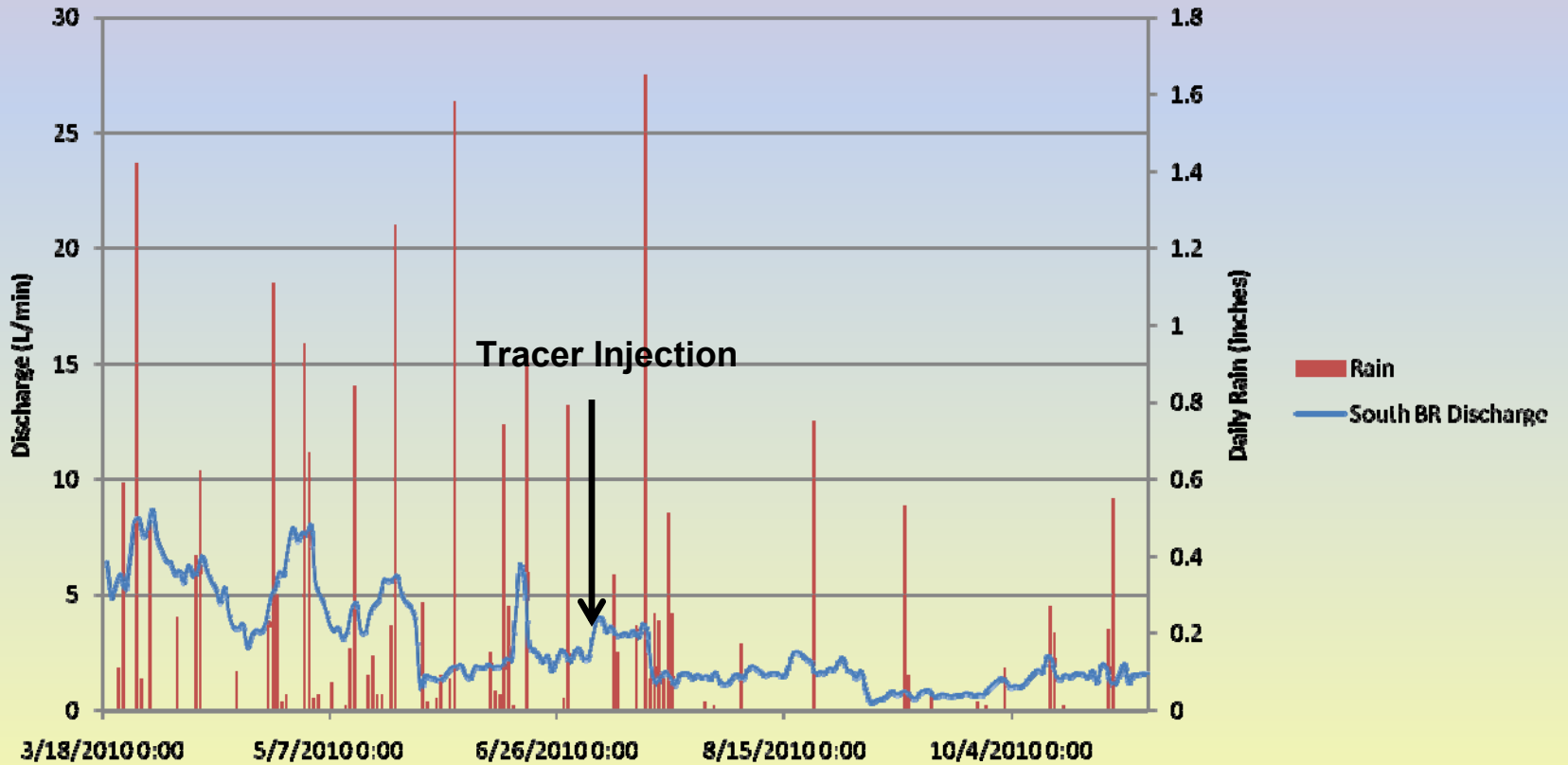
**Ferrous Iron
mg/L**

50
100
200
300
500
700

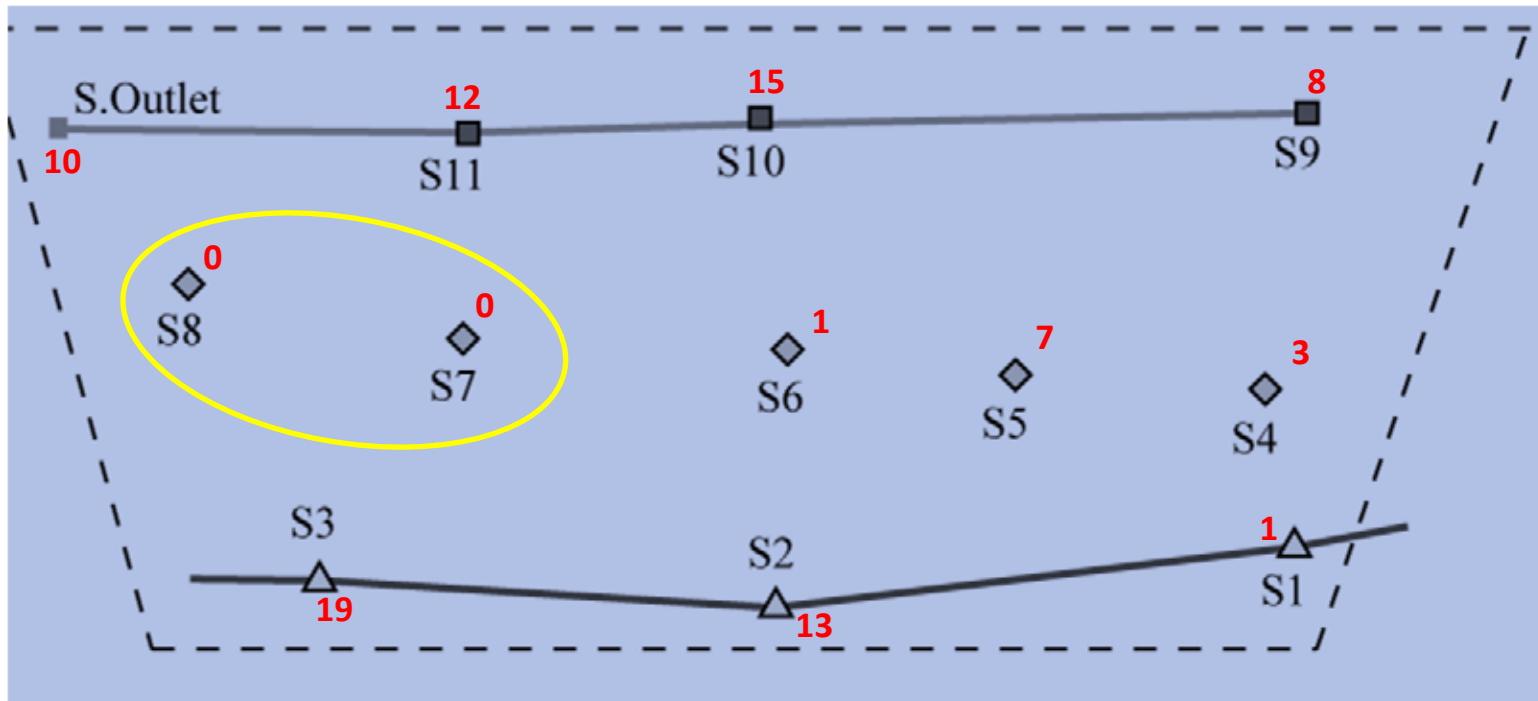
**Fall
2010**



Lacy South Bioreactor Outlet

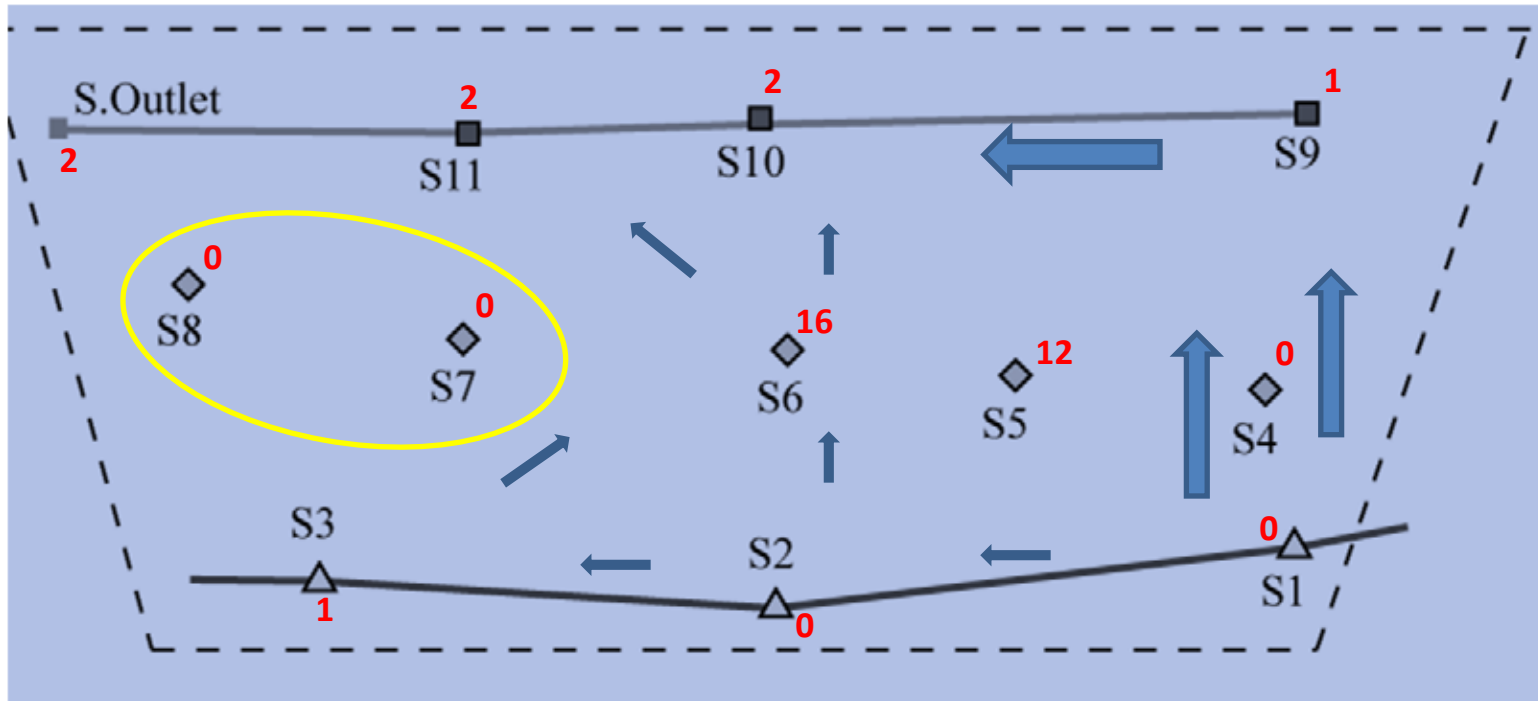


Bromide tracer introduced on 6/28/2010
Detected at Outlet on 6/30/2010 at conc. of 19 mg/L



**Bromide values
7/2/2010**

**Bromide values
7/7/2010**



Conclusions

- **Internal 3-D monitoring system enhances performance evaluation**
 - **Monitoring frequency of internal ports reveals changing extent of reducing zone and migration of acid neutralization front.**
 - **Reveals magnitude of chemical reactions and development of preferred flow paths**
 - **Residence time, critical for developing microbial-catalyzed reactions, can be determined for all monitored areas of cell from tracer injections**

Questions to be answered by continued research

- Is preferential flow path development a result of precipitate buildup?
 - Iron and aluminum oxides at neutralization front
 - Gypsum in oxygen depletion zone
 - Iron sulfides in sulfate-reducing zone
 - Determined from examination of multiple cores
- Can sulfate reducing bacteria be rejuvenated throughout neutralized zone of cell?
 - Adding simple organic compounds through sampling ports (alcohols, sugars, organic acids)
 - Summer season best time when bacterial activity is increasing as flow decreases

WELCOME TO
SHOALS
HOME OF THE
JUG ROCK

CATFISH FESTIVAL
July 4th



